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ORIGINAL ARTICLES.

I.—A Note on some Fossil Plants from the Kent Coal-field.

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(PLATE V.)

THE rapid exploration of the Kent Coal-field during the last few years has considerably increased our knowledge of the very interesting Upper Carboniferous floras there developed. In a previous paper[1] I described the plants obtained from the Waldershare and Fredville borings, and I hope before long to publish further accounts of the floras derived from several other borings. In the present note I wish to draw attention to the discovery of two fossils in Kent which appear to me to be of exceptional interest.[2]

Dictyocalamites Burri, gen. et spec. nov. (Pl. V, Figs. 1, 3, and 5.)

Two examples which appear to be members of a new genus, allied to *Calamites*, have been obtained from cores of 4 inches in diameter at the boring at Barfreston, at a depth of 2,559 feet, on the property of the Sondage Syndicate, Limited. Impressions of true Calamites are also associated. The larger fragment of the new plant is shown on Pl. V, Fig. 1, enlarged to nearly twice natural size. Part of an internode is seen with a node above, the internode being 4 cm. long and 5 cm. broad, though it is not complete. The most striking feature of the fossil is the reticulate series of ridges of the internode, which, so far as I am aware, are quite unlike anything hitherto described. These anastomosing ridges are more clearly seen on Pl. V, Figs. 3 and 5, which are enlarged views of other fragments of internodes on the same piece of core. The ridges anastomose at infrequent intervals, forming elongately fusiform reticulations. The internodes exhibit a number of large, more or less irregularly oval, pits or depressions (Figs. 3 and 5) which obviously deflect the course of the ridges in their neighbourhood. I am inclined to regard these as the points of attachment of adventitious roots. One such root is seen apparently in continuity with the stem. This is not, however, shown in the photograph. Two of the root insertions are, however, plainly seen in Fig. 3 and one in Fig. 5.

[1] Arber, Quart. Journ. Geol. Soc., vol. lxv, p. 21, 1909.

[2] [For review of Geological Survey memoir on the Kent Coal Exploration, just issued, see *infra*, p. 131.—Edit.]

The nodal region is unfortunately very imperfect, though there can be little or no doubt that the upper part of Fig. 1 really represents a node, or that the ridges of successive internodes alternate. No reliable evidence exists either of infranodal canals or of leaf-scars. As to the interpretation of the specimens, it is of course difficult to draw any definite conclusions from the present material. The anastomosing of the ridges of the internodes is, however, a perfectly definite feature, though one would wish for more perfect examples of the nodes in order to determine whether these specimens represent the external impressions of a stem, or the pith-casts of a plant allied to *Calamites*. I am inclined to adopt provisionally the former view. The evidence of roots and of root-scars favours the suggestion that we are dealing here with the external surface of a stem. The absence of infranodal canals, though not conclusive in the present material, also supports this conclusion, so far as it goes.

The external surfaces of Calamite stems are very varied. Some are almost smooth, while others possess ridges and grooves on the internodes, not very dissimilar to those of the pith-casts. The interpretation of these specimens as external impressions, characterized by a reticulation of ridges on the internodes, naturally presents less difficulties than the supposition that we are dealing here with pith-casts. On the latter hypothesis, we should be led to imagine that the vascular bundles of this plant must have anastomosed frequently, as exhibited by the lozenge-shaped areas between the ridges. This is quite contrary, of course, to any evidence we have from petrified specimens. I think a new generic name, *Dictyocalamites*, may be proposed for such fossils, whether they eventually prove to be external surfaces or pith-casts.

The following is a diagnosis of the new genus: Segmented casts or impressions of Equisetalean affinity, similar in habit to those of *Calamites*, the internodes of which are characterized by a reticulation of ridges.

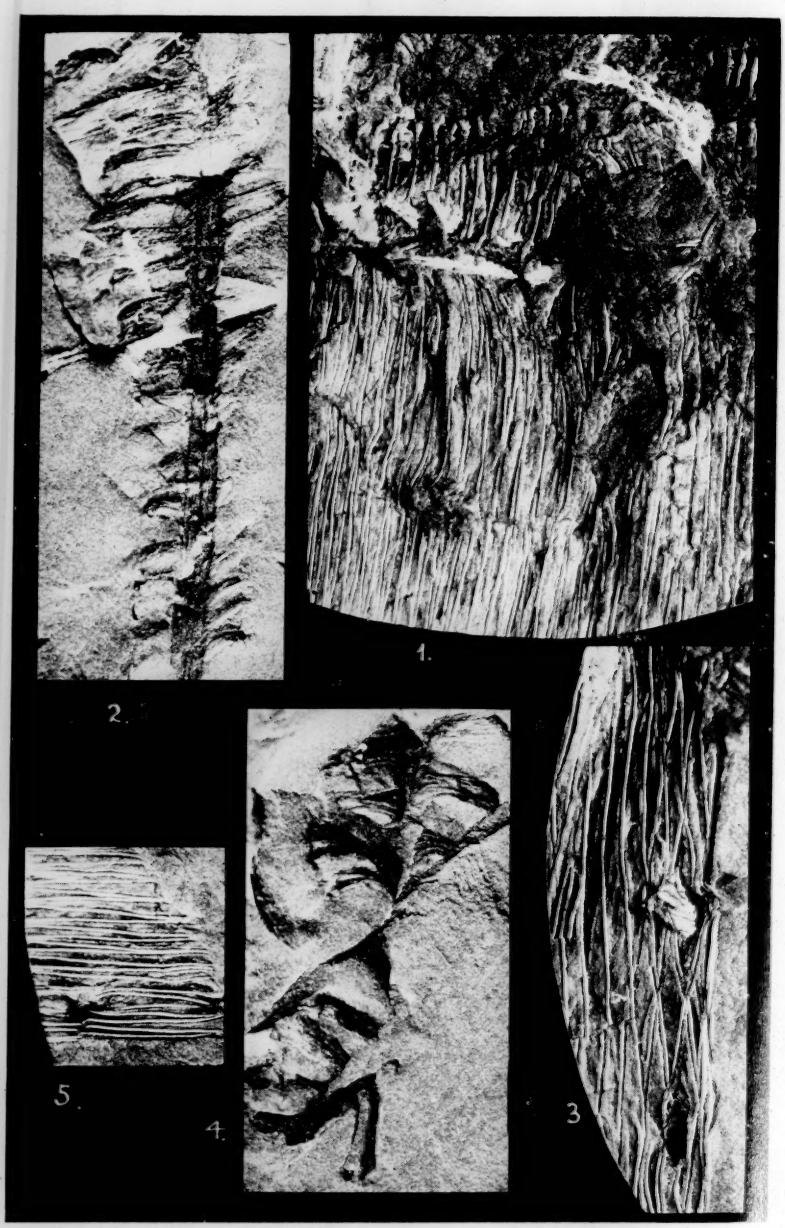
I have pleasure in naming the species after Dr. Malcolm Burr, F.G.S., who has very kindly presented the specimens figured here to the Sedgwick Museum, Cambridge.

PTEROPHYLLUM sp. (Pl. V, Figs. 2 and 4.)

The other new plant, which is of nearly equal interest, is represented by some fragments of leaves, which appear to belong to the genus *Pterophyllum*. They were obtained from the same boring at Barfreston, at a depth of 1,834 feet, in the Transition Coal-measures.

The two specimens figured on Pl. V, Figs. 2 and 4, show a somewhat stout rachis with fragments of pinnules still attached. None of the latter, however, are complete. The longest leaflet, slightly exceeding 1 cm. in length, is seen at the top of Fig. 2, which is enlarged nearly twice. The leaflets are fairly distant from one another, from 1 to 1·5 mm. broad, and appear to be slightly contracted at the base. Each has three or more parallel nerves, which fork occasionally near the base. These are seen on Fig. 4, which is three times enlarged.

There appears to be little doubt that these leaves are of Cycadophytean affinity. I have shown them to Professor Nathorst and



W. Tams photo.

Dictyocalamites and *Pterophyllum* from the Kent Coal-field.

other palæobotanists, and they agree with me in this conclusion. I believe them to be members of the genus *Pterophyllum*, one of the earliest types of leaf belonging to members of this alliance, appearing first of all in Carboniferous times. They may be compared with *Pterophyllum blechnoides*, Sandb.,[1] from the Stephanian of the Black Forest. Other species of this genus are known from the Stephanian and Permian of other parts of Germany, and especially from France. Fronds of this type are also abundant in the earlier Mesozoic rocks.

The occurrence of a *Pterophyllum*, even although the fronds are too fragmentary to warrant specific determination, in beds containing a typical Transition Coal-measure flora, is a quite unique experience in England, and, so far as I am aware, in the Westphalian rocks of Europe. Such rare cases illustrate the first slow incomings of the Cycadophyta, a group which reached its maximum during the Mesozoic period. The transition from the Palæophytic to the Mesophytic type of flora was probably a perfectly gradual one. The Mesophytic types begin to appear towards the close of the Palæozoic period. They come in very gradually, but become more numerous as we pass up through the Permian. It is not until Triassic times that they occupy the position of a dominant group. The rare occurrence of such a type of frond as *Pterophyllum*, one of the earliest known Cycadophytean fronds in the Stephanian and Permian, is thus of interest, and it is now satisfactory to find that this genus can be traced back as far as the Westphalian.

In this connexion it is interesting to recall the fact that a single twig of *Walchia imbricata*, Schimper, a plant of obvious Coniferous affinity, was described some years ago by Dr. Kidston[2] from the Upper Coal-measures of the Hamstead Colliery, Great Barr, near Birmingham. Here, again, we have one of the earliest evidences of the incoming of another great Mesozoic group, the Coniferæ.

EXPLANATION OF PLATE V.

The numbers refer to the Carboniferous Plant Collection of the Sedgwick Museum, Cambridge.

FIG. 1. *Dictyocalamites Burri*, sp. et gen. nov., showing a node and part of an internode which has reticulated ridges. No. 2259. From the Barfreston boring, Kent, at 2,559 feet. × $\frac{2}{3}$.

,, 2. *Pterophyllum* sp. A portion of a leaf showing the stout rachis to which fragments of leaflets are attached. No. 2220. From the Barfreston boring, Kent, at 1,834 feet. × $\frac{1}{4}$.

,, 3. *Dictyocalamites Burri*. Another portion of an internode, enlarged, showing the reticulating ridges and (?) scars of adventitious roots. No. 2224. From the Barfreston boring at 2,559 feet. × $\frac{2}{3}$.

,, 4. *Pterophyllum* sp. Another fragment of a leaf in which the pinnules are somewhat more perfect. No. 2221. From the Barfreston boring at 1,834 feet. × 3.

,, 5. *Dictyocalamites Burri*. A portion of another internode, showing the ridges and a (?) scar of an adventitious root. No. 2224. From the Barfreston boring at 2,559 feet. × $\frac{2}{3}$.

[1] Sandberger, *Verhandl. Naturwissen. Verein Karlsruhe*, vol. i, p. 30, 1864.
[2] Kidston, Trans. Roy. Soc. Edinb., vol. xxxv, pt. vi, p. 324, pl. i, fig. 9, 1891.

II.—On the Interglacial Gravel Beds of the Isle of Wight and South of England, and the Conditions of their Formation.[1]

By Professor Edward Hull, M.A., LL.D., F.R.S.

(WITH A FOLDING MAP, PLATE VI.)

Part I: Introduction.

Previous Authorities.—The most important work dealing with my subject is that by Mr. Thomas Codrington "On the Superficial Deposits of the South of Hampshire and the Isle of Wight".[2] In this elaborate essay, which includes all the area with which I propose to deal, the author describes the gravel terraces on both sides of the Solent, including the New Forest, showing how they were originally distributed over surfaces gradually sloping downwards on both sides towards the margin of the sea-coast from a height of about 420 feet on either hand. In the author's view, the plateau gravel beds were spread as sheets over sloping surfaces, themselves intersected by river-valleys which were widened and deepened at a subsequent period after the deposition of the beds of gravel, so as to leave abrupt faces and cliffs exposing sections of the strata. The paper, which is illustrated by sections, leaves nothing to be desired for completeness; but in order to account for the deposition of the gravel-beds he propounds a theory which I am unable to accept. It is contained in clauses 3 and 4 of the Summary (p. 549), which I here quote at length:—

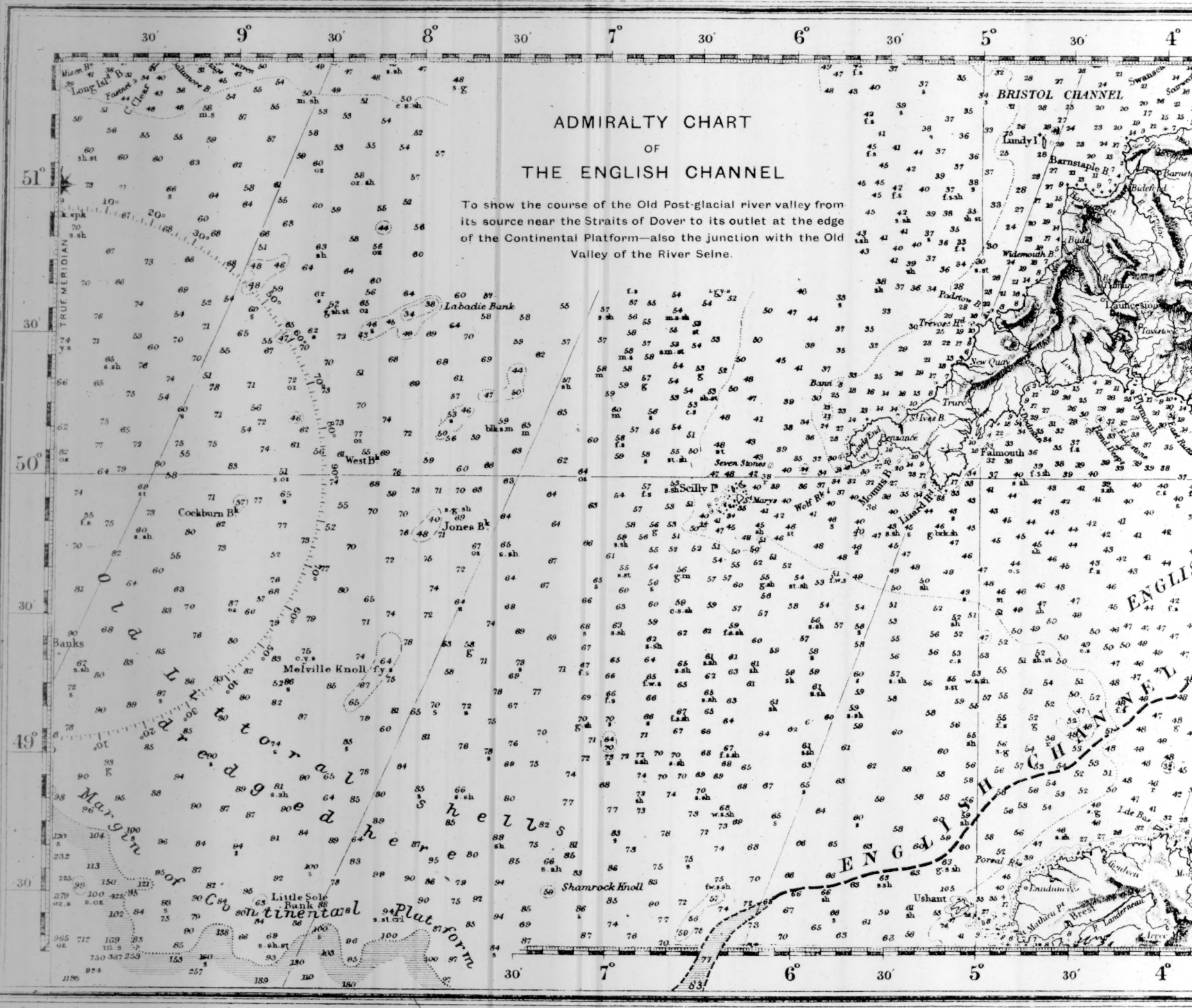
"3. The spreading out of the gravel, and the levelling of the tablelands, was probably effected in an inlet of the sea shut in on the south side by land which connected the Isle of Wight with the mainland, and opening to the eastward."

"4. A gradual elevation appears to have gone on from the time of the oldest and highest gravels down to the date of the low-level gravel-beds, by which the inlet was narrowed into an estuary which received the waters of all the rivers from Poole Harbour eastward; the Isle of Wight being still connected with the mainland."

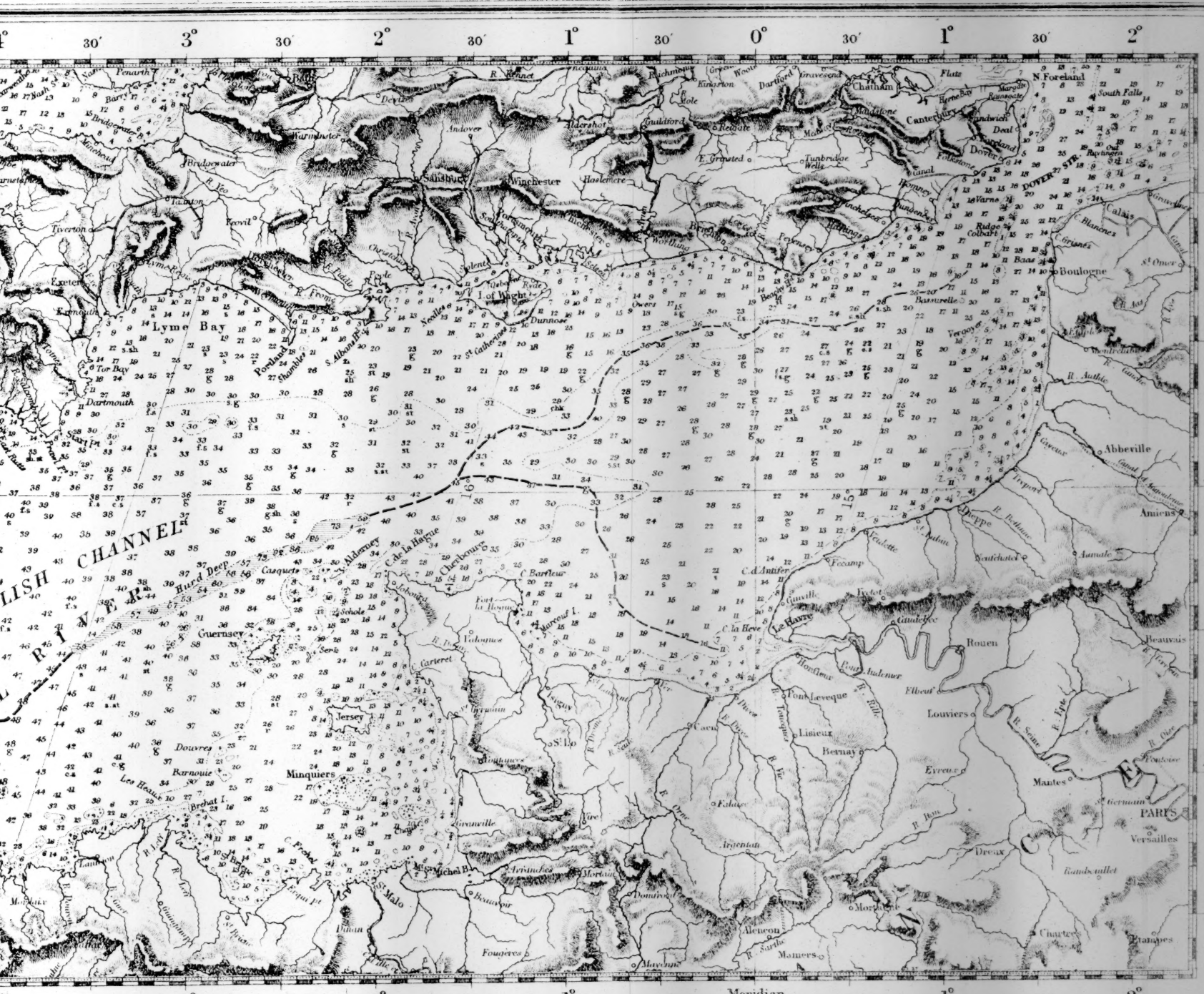
From the above quotations it will be seen that the author refers the presence of the gravels to a very local origin, and assumes the formation of a gulf by the uprising of a sort of barrier between the extreme westerly end of the Isle of Wight and the mainland. But I am unable to recognize the evidence of such an uprise of the strata. The strike of the beds from the Needles to the Isle of Purbeck is nearly E.–W. and seems to exclude the idea of a land connexion at a time when, according to Mr. Codrington's own hypothesis, there must have been a deep submergence amounting to over 420 feet. The explanation I have to offer embraces a larger area of more general conditions. At the same time I agree with the author I am quoting, that the plateau gravels are of marine origin, deposited during a gradual uprising of the land from a level of about 420–50 feet above the present sea-surface.

[1] Communicated to the Geological Society of London, November 8, 1911.

[2] Quart. Journ. Geol. Soc., vol. xxvi, 528, 1870.



ENGLISH CHANNEL R


4° 30′ 3° 30′ 2° 30′ 1° 30′ 0° 30′ 1° 30′ 2°
51°
30′
50°
30′
49°
30′
Meridian of Greenwich
CHANNEL
ENGLISH
Lyme Bay
Dartmouth
Exeter
Exmouth
Tiverton
Taunton
Bridgewater
Penarth
Bath
Devizes
Andover
Hurstbourne
Salisbury
Winchester
Aldershot
Guildford
Reigate
Haslemere
E. Grinsted
Tunbridge Wells
Maidstone
Canterbury
Chatham
Gravesend
Dartford
Kingston
Richmond
Hounslow
Windsor
Staines
Egham
Weybridge
Godalming
Farnham
Petersfield
Portsmouth
Southampton
Ringwood
Wimborne
Blandford
Dorchester
Sherborne
Yeovil
Crewkerne
Chard
Honiton
Axminster
Lyme Regis
Bridport
Beaminster
Crewkerne
Ilminster
Wellington
Tiverton
Cullompton
Tavistock
Plymouth
Torbay
Start Pt.
Prawle Pt.
Salcombe
Kingsbridge
Dartmouth
Totnes
Newton Abbot
Teignmouth
Exmouth
Sidmouth
Honiton
Ottery St Mary
Colyton
Seaton
Beer
Lyme Regis
Bridport
Dorchester
Weymouth
Portland
Shambles
St Albans Hd
St Catherines
Dunnose
I. of Wight
Needles
Hurst Pt.
Yarmouth
Cowes
Ryde
Spithead
Portsmouth
Chichester
Arundel
Worthing
Brighton
Lewes
Hastings
Rye
Winchelsea
Dungeness
Romney
Hythe
Folkestone
Dover
Deal
Sandwich
Ramsgate
Margate
Reculver
Herne Bay
Whitstable
Faversham
Sittingbourne
Rochester
Strood
Milton
Sheerness
Isle of Sheppey
Queenborough
Harwich
Ipswich
Woodbridge
Aldeburgh
Orfordness
Lowestoft
Yarmouth
Cromer
Wells
Lynn
Boston
Spalding
Peterborough
Stamford
Grantham
Newark
Lincoln
Gainsborough
Doncaster
Selby
York
Thirsk
Northallerton
Darlington
Durham
Newcastle
Morpeth
Berwick
Edinburgh
Leith
Dunbar
Haddington
Musselburgh
Jedburgh
Kelso
Coldstream
Berwick
Alnwick
Belford
Bamburgh
Farne Is.
Holy Island
Tweed
Tyne
Wear
Tees
Humber
Trent
Ouse
Derwent
Nene
Great Ouse
Wash
Thames
Medway
Mole
Wey
Arun
Adur
Ouse
Cuckmere
Rother
Brede
Medway
Stour
Orwell
Deben
Alde
Yare
Waveney
Little Ouse
Lark
Cam
Welland
Witham
Bain
Ancholme
Hull
Aire
Calder
Don
Wharfe
Swale
Ure
Nidd
Tees
Wear
Tyne
Coquet
Aln
Tweed
Forth
Esk
Leith
Tay
Dee
Spey
Findhorn
Ness
Caledonian Canal
Loch Ness
Loch Lochy
Loch Oich
Loch Linnhe
Loch Eil
Fort William
Ben Nevis
Glencoe
Loch Leven
Loch Etive
Oban
Mull
Iona
Staffa
Tobermory
Skye
Portree
Loch Carron
Loch Alsh
Kyle Rhea
Sound of Sleat
Loch Hourn
Loch Nevis
Loch Morar
Loch Shiel
Fort Augustus
Inverness
Nairn
Forres
Elgin
Banff
Cullen
Buckie
Portsoy
Fraserburgh
Peterhead
Aberdeen
Montrose
Arbroath
Dundee
Perth
Stirling
Falkirk
Linlithgow

In the Geological Survey Memoir by the late Mr. Bristow (second edition, by Messrs. Clement Reid and Aubrey Strahan, 1889) the plateau gravels are again described very much as done by the previous author, but necessarily more in detail. They are recognized by the authors as of great antiquity, and that since their deposition they have been traversed and broken into by the rivers on both sides of the Solent. But the authors do not appear to have arrived at any clear view regarding their origin and mode of formation, and in one case where the gravel is abruptly broken off at the edge of the Cliff above Alum Bay, the attempt to account for it is apparently abandoned as hopeless. I hope to be able to show that its position can be clearly accounted for.

Part II.

Terraces.—I may here be allowed to interpose a note regarding the physical features which we call 'terraces', or under the French form we call 'plateaux'. There are no more certain indications of changes of level under various conditions than terraces, whether by the sea-coast, the borders of lakes, or of rivers; and wherever I have gone I have studied their conditions with special interest. I have observed their position and relative levels along the coast of the British Isles, in England, Scotland, and Ireland; along the borders of the Mediterranean, and the banks of the Nile, the Dead Sea, and the River Jordan; in all these countries they indicate the levelling effects of the sea, the lake, or the river, at successive periods; and they are evidence of former submergence. It is from such evidence that we draw the inference that (as Mr. Codrington has correctly inferred) the coast of Dorset and the Isle of Wight has been submerged to a depth of over 420 feet. But having regard to the permanent level of the ocean waters, is it conceivable that this submergence was confined within the limits of this area alone? Why should it not have extended in all directions as far as the hills and uplands, rising into higher altitudes to the north, west, and east? For it cannot be questioned that the physical features of this region had been determined before the period when the plateau gravel beds were being accumulated.

Isle of Wight: Evidence of an Ancient Sea-margin.—Some few years ago, when on a visit to this island, with the aid of an aneroid I spent my time in making observations of level, and, amongst other places, I took the level of a gravel-bed at the summit of the cliff overlooking Alum Bay, and also of the remarkable gravel terrace south of Newport known as St. George's Down. My interest was greatly aroused on discovering that the aneroid readings were very nearly the same in both cases—approximating to 400 feet above the sea, or a little under. It then occurred to me that we had in these readings evidence of the existence of an ancient sea-margin. On ascending to the top of the St. George's gravel-pit, I found myself on a nearly level terrace extending far westwards, and breaking off in an abrupt cliff on the north and west sides. The beds were found to consist mainly of rolled chalk-flints, rudely but distinctly

stratified. The section of the gravel cliff is fully described in the Survey Memoir.[1]

The gravel-bed on the summit of the cliff above Alum Bay is distinctly visible from the deck of the ship anchored in the bay below; and its horizontal stratification, resting on the nearly vertical strata of the Tertiary Series, forms one of the most interesting geological features of the country. Its presence there is easily explained. It once extended westwards to an undefined distance, but with the underlying Tertiaries it has been worn back along the side of the ridge of the Chalk, which now stretches to the Needles, but once extended to a greater distance towards the Isle of Purbeck. The Chalk ridge at the Tennyson Monument rises to a level of 483 feet, or somewhat under 100 feet above the level of the gravel beach from which the flint pebbles were derived by ordinary wave action. It is impossible to conceive of a more excellent example of the production of shingle at the base of its cliff at a former epoch, such as we are able to observe along our coasts at the present time.

Part III.

Dorset and the South of England.—It is unnecessary for me to describe at any length the plateau gravels, as they have been so fully described by Codrington and the officers of the Survey, while they are represented on the 1 inch Survey Map. That there are numerous deposits of sand and gravel at low levels along the coast of Southampton Water and the Solent is well known, and they are of peculiar interest as containing evidence of man's presence and of extinct animal remains. But what concerns us most in regard to the present inquiry is the upper limit of the plateau gravel beds to be found in the New Forest at levels corresponding very closely to those in the Isle of Wight. By way of illustration I shall refer to one or two examples visited by myself on the occasion of a recent visit with members of the British Association. Lyndhurst Church stands on Tertiary beds, at a height of 139 feet, but to the north and west the ground rises gradually, and on reaching Stony Cross Plain at a height of 373 feet we find ourselves on the margin of an extensive terrace, rising at Long Cross Plain to a height of 414 feet, but sloping gradually, in the direction of the River Avon, to the west; the average level is about 350 feet. The plain is formed of beds of gravel composed chiefly of rounded flint-pebbles and occasional bands of sand, and numerous shallow sections are supplied by the pits which are worked for road-stone to a few feet from the surface, which extends unbroken to the edge of the valley of the Avon and its tributaries. It is impossible not to recognize the similarity of the conditions on both sides of the Solent, though separated by an interval of about 25 miles. In each case we have beds of rolled flints, spread out in sheets with flat, or slightly inclined, surfaces, and reaching levels of nearly 400 feet above the sea, from which they descend by gentle slopes to the sea-margin. The origin of the flint-pebbles is beyond

[1] *Geol. Isle of Wight*, 2nd ed. The correct level of the upper surface of St. George's Down, as given in the Ordnance Map, is 365 feet. Probably that of the cliff at Alum Bay is somewhat lower.

question, and is to be found in the uplands of the Chalk formation, rising in the case of the Isle of Wight into the ridge which stretches from the Needles to Foreland Point, and in the case of the mainland rises into the great expanse of Salisbury Plain. These formed the land-margins of the area at a period of depression to the extent of over 400 feet. The epoch of this depression is not difficult to determine. That it was post-Tertiary is clear from the relations of the plateau gravels of the Tertiary beds as seen in the Isle of Wight, and it was after the period of disturbance which raised the Cretaceous and Tertiary beds into their present inclined position, and subjected them to an enormous amount of erosion. Thus we arrive at the conclusion that the plateau gravels are the representatives in the South of England of the Interglacial sands and gravels of the centre, east and north of England and Wales.[1]

Part IV.

Having thus endeavoured to show that the plateau gravels were deposited under the waters of the sea, and that the materials of which they are composed were derived chiefly from the erosion of the adjoining unsubmerged Cretaceous lands during an epoch of depression, it becomes necessary to refer back to the preceding epoch, in order to determine the physical changes which led up to succeeding conditions, and on this subject the evidence is not less clear and substantial, and while in my handling of this subject I shall adduce the support of an authority of the highest weight, that of the late Mr. Godwin-Austen.[2] The preceding epoch was one of elevation of the land, and of this the evidence is of two distinct kinds, going to show that the uplift was sufficient to lay dry the bed of the English Channel and bordering sea round the coasts of England and France, producing that remarkable now submerged feature known as the "Continental Shelf".

This brings me to refer to the Continental Platform. This physical feature consists of a gently shelving plain extending from the existing coasts, and stretching out into the Atlantic for a variable distance, 50 miles or more, and at its outer margin breaking off in a steep, sometimes precipitous, descent into the abyssal depth of the ocean. Its margin generally coincides with the isobathic contour of about 100 fathoms opposite the mouth of the English Channel, and it is traversed not only by channels of rivers continuous with those now entering the Atlantic along the western coast, but also by a submerged river valley which is entirely under water, which I have

[1] In Lancashire these Interglacial sand-beds with marine shells are overlain by an Upper Boulder-clay of marine origin, as shown by the shells it contains (*Turritella*, *Fusus*, *Purpura*), and a fine section showing this superposition of the Upper Boulder-clay on the Interglacial sands is laid open on the banks of the Ribble above Preston. I have given an account of these Pleistocene deposits in *Contributions to the Physical History of the British Isles*, 1882, chap. xiii. The sands and gravel are probably the representatives of the "Middle Glacial beds" of Messrs. Wood and Harmer, of Norfolk.

[2] In his communication to the Geological Society entitled "Valley of the English Channel": Q.J.G.S., vol. vi, 1850.

ventured to name "the English Channel River". It will be necessary for me to return to this subject later on. (See Map, Plate VI.)

The margin of the Continental Platform was traced by the late Mr. Hudleston,[1] and described before the British Association at Bristol, but without the intersecting channels; and also by Dr. Nansen, Professor Spencer, and myself,[2] and is now recognized as a former coastline at a time when the sea-bed was about 100 fathoms above its present level. On the platform thus circumscribed the whole of the British Isles and Western Europe are planted. It is needless to say that the physical features there determined have been based on the isobathic contours which may be traced by means of the soundings recorded on the Admiralty Charts.[3]

Littoral Shells of the Channel Bed.—The statements of Godwin-Austen regarding the shells dredged from the bed of the Channel at depths of 60 or 70 fathoms (360–420 feet) is confirmation of the view that the Channel was contiguous with dry land at a former period. He says: "The great proportion of these shelly materials (forming the floor of the Channel) has come from a contiguous higher zone; but mixed with these, and in considerable abundance, are the pounded fragments of the commonest littoral species. Thus the *Haliotis tuberculata*, which lives about Brittany and the Channel coast just below ordinary low water, has its fragments carried out 50 miles from the nearest coast, and with it abundantly *Patella vulgata*", and at the Little Sole Bank in a depth of water of 60 or 70 fathoms *Turbo littoreus* is found near the edge of the Continental Platform, where the water descends to great depths; and the conclusion which he draws is that the whole of the Channel valley had at some former period a higher level than at present.[4]

Again, in the paper read before the Society by the same author "On the Pleistocene Period", he states that in order to account for certain phenomena of this region it is necessary to infer an elevation of great amount, such as would place the whole of the higher portions of this country in regions of excessive cold.[5]

The English Channel River.—I now come to state the evidence for the existence of the submerged river valley to which I have already alluded, the presence of which on the Admiralty Chart is conclusive of former land conditions over this region. So clear is this submerged channel, that the officers engaged on the soundings have traced its course for a distance of 60 miles and named it "The Hurd Deep", after its discoverer. Its total length is about 300 miles from its source near the Straits of Dover to its outlet at the margin of the Continental Platform, where it has worn a deep channel into the ocean. Its channel appears to have been swept free of sediment where the English Channel is narrow between Cape de la Hague and Portland Bill, and the tidal current is exceedingly strong; but when

[1] British Association Report, Bristol. [2] Ibid.

[3] The margin of the platform nearly coincides with the meridian 9° 5′, W., and its position at the edge of the steep descent has been recorded by Godwin-Austen from soundings by himself (1850). "Valley of the English Channel": Q.J.G.S., vol. vi, p. 76.

[4] Ibid., p. 85. [5] Ibid., vol. vii, p. 130.

the width increases to nearly double the distance, and the current has proportionately become slower, the sediment seems to have silted up the channel so as to be, for some distance, indeterminable.

Enough has probably now been advanced to show that land conditions prevailed during a period included within the time-limits of the great Post-Pliocene or Glacial Uplift. The conditions we have been considering were only those of a stage in the still greater uplift, and subsequent descent of the land; and as the submerged river valleys of Western Europe are traceable to a depth of 6,000 feet below the present sea-level, where they open out on the Atlantic floor, it is evident that the ocean-bed and the adjoining lands were uplifted into those altitudes of 'excessive cold' postulated by Godwin-Austen, who with that prescience for which he was so remarkable had almost advanced a prophetic solution of the hitherto mysterious problem of the cause of the 'Great Ice Age', a solution which for my part I am prepared to maintain as one sufficient in itself, and in harmony with the physical conditions revealed by the deep-sea soundings.[1]

Part V: Conclusion.

I have endeavoured to add a chapter to what has been so ably written by previous authors on the geological history of this interesting island and its neighbouring lands, based on individual strata of gravel, apparently of little interest in comparison with the fine assemblage of Tertiary beds on which they repose, but, as I have endeavoured to show, having a not unimportant place in the geological and prehistoric record.

It now only remains to recapitulate the physical changes which in this district at least took place at the close of the Tertiary period down to the present time. We begin with uprise of the Tertiary and Cretaceous beds.

1. Earliest stage. Axis of the Isle of Wight. Stratigraphical upthrust of the Cretaceo-Tertiary beds by lateral pressure; formation of an E.-W. axis, followed by denudation of the strata and long lapse of time.

2. Regional uplift and formation of the Continental Platform, uniting Europe and the British Isles—English Channel River Valley.

3. Submergence to extent of 400 feet and over in South of England, increasing northwards and reaching from 1,200 to 1,300 feet in Wales and Ireland. Beds of gravel and sand in Surrey, Norfolk, the Midlands, Lancashire, and Wales.

4. Re-elevation into present condition of land and sea; formation of low terraces, with works of art and extinct animals. The latest elevation of low-level gravels being probably within the period of the Roman occupation.

[1] The author has in preparation a monograph on the "Sub-oceanic Physiography" of the Atlantic Ocean, showing by charts the position of the submerged terraces and river-channels which descend to depths of 6,000 or 7,000 feet, and are continuous with the existing rivers of Europe.

III.—Description of a Diamantiferous Gem-Gravel from the West Coast of Africa.

By F. H. Hatch, Ph.D., M.Inst.C.E., Vice-President of the Institution of Mining and Metallurgy.

THE material described in this paper was handed to me by the Liberian Development Company (to which I acted for some time as technical adviser) and was obtained in the course of prospecting operations prosecuted by that Company at Banja Ta (Montserrado) on the Jiblong and Bor Rivers (tributaries of the Junk River), some thirty miles inland from Monrovia, the chief port of the State of Liberia.

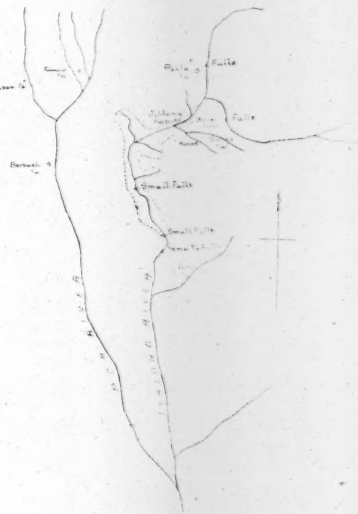
Diamonds and gold were discovered in the alluvial gravels of these rivers by the late Mr. George G. Dixon, and the concentrates submitted to me for examination were brought to this country by Mr. Dixon at the end of 1910. Mr. Dixon returned to Liberia soon after I had seen him; but unhappily he succumbed to an attack of malarial fever early in 1911. The subsequent prospecting work was carried on under the direction of his assistant, Mr. S. M. Owen, who at the end of the working season of 1911 brought me a series of rock-specimens and cores from boreholes (most of which were put down near the rapids to be referred to presently), so that I am enabled also to give a brief description of the solid geology of the district.

The bed-rock on which the alluvial gravels rest consists of an ancient floor of crystalline rocks, comprising: quartz-felspar-biotite gneiss with accessory sphene and zircon; garnet-hypersthene-biotite gneiss, composed of abundant red garnet, strongly pleochroic hypersthene, brown mica, chlorite, together with granulitic quartz and a small quantity of striated felspar; and coarsely foliated hornblende schist, consisting of green hornblende, plagioclase, quartz and sphene. All these rocks present a well-marked banding, the general strike of the country as reported by Mr. Dixon being N.E. and S.W., with a dip to the S.E.,[1] and give the impression of belonging to an ancient sedimentary series which has been profoundly modified by metamorphism. Associated with them are dark-coloured basic intrusions which, as the microscope shows, consist of water-clear plagioclase, green hornblende and hypersthene with marked granulitic structure, constituting a rock of the pyroxene-granulite or norite type.

Except in the bed of the River Jiblong itself, where comparatively unweathered specimens of the rocks can be obtained from the bars that stem the flow of the water and thus give rise to falls and rapids, all the rocks are entirely replaced at the surface by red and yellow lateritic or whitish kaolinized products; but excellent material for microscopic examination was obtained in the shape of cores from the diamond drill which was freely used in the prospecting operations of the Company. The object of the prospecting was two-fold: (1) to ascertain the quantity and value of the diamantiferous gravel, and (2) to find if possible the source from which the diamonds came. It was with the latter object that the borings were made. To ascertain the extent and value of the diamantiferous gravel the following method of prospecting was adopted: First, sites for pits were marked out at

[1] Cf. J. Parkinson, "A Note on the Petrology and Physiography of Western Liberia": Quart. Journ. Geol. Soc., vol. liv, 1908, p. 313.

fixed intervals across the alluvial flats. The pits were then sunk, the overburden being discarded and the gravel washed. Concentration was effected by the ordinary methods of sluicing and sizing by sieving, the final product being obtained by hand-jigging. From this the diamonds were recovered by hand-picking. The following is the number and weight of diamonds found during the prospecting operations carried on during 1910 and during the first part of 1911: 247 stones, weighing $85\frac{19}{64}$ carats, in the Jiblong River, and 22 stones, weighing $4\frac{3}{64}$ carats, on the Bor River. The largest stone found weighed $4\frac{19}{64}$ carats. Diamonds were found in the Jiblong River and in its alluvial flats for a distance measured along the river of a little over a mile and a half. This stretch of the river is situated between the rapids below the Pakla Ta Falls and the small falls above the Yema Ta Falls (see Map). This stretch of country is comparatively flat, but measured [1] from the top of the Pakla Ta Falls to the bottom of the Yema Ta Falls the river has a total drop of about 100 feet.



Sketch-map of the Jiblong and Bor Rivers from a survey by S. M. Owen. Scale, 1 inch = 1 mile. The area in which diamonds have been found is indicated by a pecked line.

The average width of the flats in which the diamonds were found is 238 feet. The average thickness of the diamantiferous gravel between the overburden and the bed-rock was found to be 6 feet. Diamonds were also found in the Bor River which joins the Jiblong at Careysburg, three miles below the Yema Ta Falls, but no extensive deposit exists in this river valley.

The samples of the 'deposit' or concentrate from which the diamonds had been picked, consisted of a mixture of heavy minerals, together with quartz, limonite, and rock fragments. The quartz was

[1] According to a survey of Mr. S. M. Owen, A.R.S.M.

easily removed by a preliminary treatment with bromoform of density 2·9. The residue still contained limonite, some rock fragments, and particles of tourmaline, the bulk of which was removed by treatment with a borotungstate of cadmium solution, having a density of 3·4. A mixture of heavy minerals was then obtained which could only be separated by hand-picking with the aid of a lens. This, although a tedious task, was found to be quite practicable; and a number of parcels of distinct minerals were thus obtained, the final determination of which was arrived at by taking the density, testing the hardness and streak, and, where practicable, measuring the crystal angles. In those cases where there was sufficient material, chemical tests were also made, both by dry and wet methods.

For permission to carry out this work in the Chemical Laboratory of the Mineralogical Department of the University of Cambridge, I am indebted to Professor W. J. Lewis, F.R.S., and for assistance in making a few goniometric measurements of crystals, I have to thank Mr. Arthur Hutchinson, Demonstrator of Mineralogy in the University of Cambridge.

Of the samples examined the two principal ones were: A (No. 30) gravel from the upper flats, and B (No. 31) from the lower flats. Sample A consisted of kyanite, corundum, pyrites, ilmenite, zircon, rutile, epidote, and gold. Sample B consisted of garnet, kyanite, pyrites, chromite, magnetite, hæmatite, zircon, and diopside. It will be observed that in sample B from the lower flats the minerals garnet, chromite, magnetite, hæmatite, and diopside occur, which are not represented in the sample from the upper flats; and, moreover, the garnet occurs in great abundance. It is obvious, therefore, that some source of supply was available for the formation of the gravels of the lower flats which did not exist in the upper reaches of the river. In all probability this was the garnetiferous gneiss already mentioned. The presence of gold in sample A was accidental, as the gold from both samples had been previously removed. The particle of gold found in the sample was coated with amalgam, and its true character only became apparent after driving off the mercury by heat.

Diamond.—Of the uncut diamonds still in the London office of the Liberian Company and examined by me, some are perfect octahedral crystals showing the usual rounded edges and striated faces due to vicinal forms. Others are irregular cleavage fragments showing no original crystal faces, while others again are partially bounded by original faces and partly by octahedral cleavages. There are also flattened rudely triangular forms (macles) due to twinning on the spinel type. In many cases the faces are smooth with occasional triangular pittings; and, as a rule, there is no sign of true abrasion. Some of the faces of the crystals, however, have a roughened, fretted, or frosted surface which must, I think, be attributed to corrosion while the crystals were still in the igneous magma in which they were formed, rather than to any subsequent attrition. Many of the stones are pure white and flawless; but some have a yellow or brown tinge and there is the usual proportion of spotted material. The average value of the whole parcel has been appraised by A. E. North and Co., of Hatton Garden, at £2 11*s.* per carat.

Gold.—An examination of the gold obtained by washing and now in the London office of the Liberian Company shows that it has the usual characteristics of the noble metal when obtained from alluvial sources. It is fairly coarse, but not nuggety; the grains are of irregular shape and are usually somewhat flattened. The colour is a beautiful dark yellow, due to the low proportion of silver, the fineness on assay being 971 per 1,000 parts.

Kyanite.—This, the most abundant mineral in sample A and the second most abundant in sample B, occurs in pale-blue to pale yellowish-green glassy fragments bounded by faces of the prismatic zone with predominant macro-pinacoid (100) and perfect cleavages parallel to the same face. Many of the fragments are flecked with minute black inclusions apparently of an iron-ore (magnetite?). The density was determined as 3·72.

Corundum.—This mineral is abundant in sample A, but absent from sample B. It occurs as cleavage fragments with no signs of rounding; colour, a dull pink with imperfect translucency. The basal plane (111) shows the triangular reticulation of fine lines due to lamellar twinning on the rhombohedron (100). The density was determined as 4·0.

Garnet.—This, the most abundant mineral in sample B, is absent in sample A. It is a blood-red variety, probably that known as pyrope. The fragments are of an irregular shape, determined by the uneven fracture and imperfect cleavage characteristic of the mineral, and present no crystal faces. The density was determined as 3·98.

Rutile.—This mineral is fairly abundant in sample A, but was not found in sample B. The fragments present dominant faces of the prism zone with vertical striation. The metallic-adamantine lustre is a predominant characteristic. Fractured surfaces show a reddish colour and there is a slight translucency at the edges. The density was determined as between 4·1 and 4·4.

Zircon.—A few crystals of zircon were found in both samples. One or two are almost perfect crystals—the prism (110) terminated by the pyramid (111). Colour, dark brown; lustre, vitreous. The density was determined as 4·75. Some colourless crystal fragments in sample B possessing strong double refraction and a high index of refraction (greater than that of methylene iodide) appear to be a special variety of this mineral. A goniometric measurement of the angle between two adjacent faces gave 48°, which corresponds closely to the angle (111) (110) = 47° 50′.

Chromite.—This mineral is fairly abundant in sample B, in rather small iron-black grains with sub-metallic lustre, giving a blackish-brown streak. As a rule the grains are irregular with conchoidal fracture or rounded, but one showed the spinel type of twinning. Fusion with borax gave the characteristic chromium reaction. The density was determined as 4·92.

Ilmenite.—This mineral occurs in sample A in tabular iron-black fragments with brilliant metallic lustre. Goniometric measurement gave the following results:—

$$111 : 100 = 57° 59′$$
$$111 : 31\bar{1} = 61° 44′$$

which agree sufficiently closely with those of ilmenite.

The presence of titanium was also proved by the yellow colour obtained with peroxide of hydrogen in the sulphuric acid solution, and by the blue colour obtained with tin in the hydrochloric acid solution. The density was determined as 4·72.

Hæmatite.—A few rounded reddish-black grains of this mineral were found in sample B. They are characterized by a brilliant metallic lustre on the surface, but are partially converted to limonite in the interior. Hence the low density obtained, viz. 4·6. The streak was cherry-red.

Magnetite.—A few small black grains with metallic lustre are present in sample B. They are strongly attracted by a small bar magnet.

Iron Pyrites.—This mineral is present in both samples in irregular fragments, but is more abundant in sample A.

Diopside.—One grain of this mineral was found in sample B. It is green and translucent with a refractive index of 1·69. It shows the rectangular prismatic cleavage and two pinacoidal cleavages, one of which appears to be a diallagic parting. The density was found to be 3·4. It is probably the chrome-diopside variety.

Epidote.—One cleavage fragment of this mineral was found in sample A. It presents the characteristic pistachio-green colour and basal cleavage.

From this examination it is evident that the bulk of the particles making up the finer material of the gravels consists almost entirely of minerals that possess a high capacity for resisting weathering—such as quartz, the various oxides of iron, corundum, kyanite, garnet, tourmaline, zircon, and diamond. On the other hand, the readily decomposable minerals, such as members of the felspar, amphibole, and pyroxene groups, are, with one exception, conspicuous by their absence. The obvious conclusion to be drawn from this fact is that these alluvial gravels are not derived directly from the crystalline rocks, but come intermediately from the lateritic weathering products by which these are replaced at the surface and which would naturally fall an easy prey to river erosion.

IV.—Note on the Molar Tooth of an Elephant from the Bed of the Nile, near Khartum.

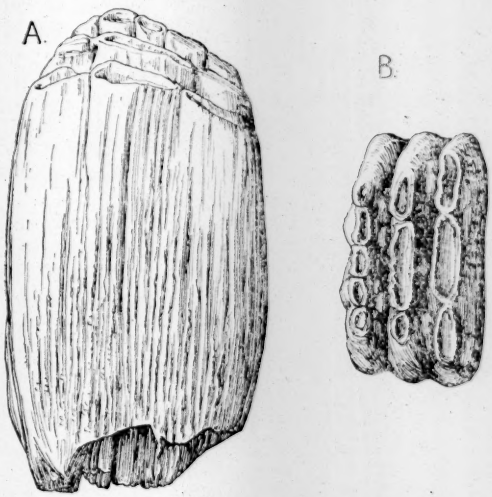
By C. W. Andrews, D.Sc., F.R.S. (British Museum, Nat. Hist.).

In sinking the caissons for the construction of the bridge over the Blue Nile near Khartum, a considerable number of bones have been found, from time to time, in the alluvial beds, at depths of 60–68 feet below the level of low Nile. These specimens were obtained by Messrs. Hinckley, Stephen, and Le Bailly, and are now deposited in the collection of the Geological Survey of the Sudan at Khartum.

Most of the specimens have been sent to me for determination by Mr. G. W. Grabham, Geologist to the Sudan Government. The bones are all black or nearly black, very heavy, and highly mineralized through the infiltration of silica and iron, so that they

present an appearance of much greater age than is usual in bones from post-Tertiary deposits. Mr. Grabham informs me that in this region these peculiar characters of preservation are very rapidly acquired, a friend of his, Mr. Bird, having found recent bones thrown by the natives into an old well, blackened and mineralized in a similar manner.

The specimens so far determined are remains of elephant, hippopotamus, a small giraffe, an antelope (? *Tragelaphus*), and a Siluroid fish. All these are, or were till comparatively recent times, living in the district. Lately, however, I have received from Mr. Grabham a specimen which seems to be of greater interest. It consists of three plates of the molar tooth of an elephant, which is certainly not the African elephant, the only species at present living on the continent.



Portion of a molar tooth of an elephant from Khartum. A, front view; B, crown view. $\frac{1}{3}$ nat. size.

It is unfortunate that the specimen is so incomplete, but careful comparison with other elephant teeth renders it possible to arrive at fairly definite conclusions as to the relationships of this form.

The specimen (see Figure) consists of three plates probably from the hinder part of an upper molar. The plates are broad and much thicker than the bands of cement interposed between them, and their enamel is fairly thick and raised into a series of low vertical ridges, one on the middle of the anterior face being a little the most pronounced, but not sufficiently so to produce a marked prominence or loop on the outline of the surface of wear, such as is usual in *Elephas antiquus*. The posterior of the three plates is just coming into wear, the worn tips of the digitations forming five oval islands of enamel. The next plate has a wear-surface consisting of a larger median area, on either side of which is a smaller one. In the next

also there are three distinct surfaces, but they are more nearly equal in size. The dimensions of this specimen are—

Greatest width of posterior plate	10·0 cm.
Greatest height of posterior plate (just in wear) .	20·0 ,,
Outside antero-posterior diameter of middle surface of wear of anterior plate	1·5 ,,
Thickness of enamel (average)	3–4 mm.

In the thickness of the plates and in the form of the wear-surfaces of the ridges, this tooth, so far as preserved, nearly resembles those of *E. meridionalis*, but, on the other hand, it differs widely from that species in the much greater height of the plates, which, in this respect, approach those of some specimens of *E. antiquus*, particularly some figured by Pohlig[1] under that name. As a rule, however, in that species, not only are the teeth not nearly so wide as in the present specimen, but the discs of wear usually show a marked mesial expansion, and there is a distinct loop in the enamel on the posterior side of the ridges at least.

Several other species of fossil elephants have been recorded from various parts of Africa. Of these *E. jolensis* and *E. atlanticus*, from Quaternary beds of Algeria, have been figured and described by Pomel.[2] Of these *E. jolensis* presents some likeness to our fossil, but its teeth are narrower, and it seems to approximate rather to *E. antiquus*. *E. atlanticus* approaches *E. africanus*, and the width of the plates and of the cement between them is greater than in the present form, in which, moreover, the tooth crown seems to have been higher.

Professor W. B. Scott[3] has described an elephant (*E. zulu*) from beds presumed to be of Pliocene age on the coast of Zululand. In this species the molars seem to have had lower and at the same time narrower crowns, though this latter character may, in part, be because the specimens described are from the lower jaw. The enamel is thicker and more crimped, and there is a well-marked enamel loop at least on the hinder side of the discs, which have a slight median expansion. *E. zulu*, in fact, seems to approach *E. antiquus* and *E. africanus* in the several points in which it differs from our specimen.

The tooth of the so-called *E. priscus*, figured by Falconer, differs in having a lower crown, discs more expanded in the middle, usually with distinct loops of enamel, and turning forward at their outer end.

Recently, Professor E. Haug[4] has given an account of a mammalian fauna from the River Omo, north of Lake Rudolf. Among the specimens are portions of the tusks and molars of an elephant, a milk molar of which is said to closely resemble one of *E. meridionalis*.

[1] "Dentition und Kraniologie des *Elephas antiquus*, Falc.": Nova Acta Leop. Carol. Deutsch. Akad. Naturforsch., Bd. liii, No. 5, pl. v, fig. 2, 1888.

[2] *Carte Géologique de l'Algérie* (Paléontologie—Monographies): Les Eléphants quaternaires. Alger, 1895.

[3] Third Rep. Geol. Surv. Natal and Zululand, 1907, p. 259, pl. xvii, fig. 6; pl. xviii.

[4] Haug, *Traité de Géologie*, vol. ii: Les périodes Géologiques, fasc. iii, p. 1727, pl. cxxx, 1911.

The collection also includes remains of a large *Dinotherium*, which seems to indicate that the beds are older than those containing the tooth now described. Possibly, however, the *Dinotherium* may not be from the same horizon as the elephant, in which case the latter may be the same species as our specimen.

A fragment of a molar, such as is here described, is not sufficient to found a new species on, but it shows that in the Sudan, as in other parts of Africa, the modern African elephant was preceded by a species more nearly approximating to forms found in other parts of the world. In this case the form preceding the modern species seems to have been practically an *E. meridionalis*, in which the molars had become much more hypsodont than in the European specimens.

It is greatly to be desired that, if possible, further collections be made from the deposits in which this interesting tooth was found.

V.—The Age of the Morte Slates.

By Dr. J. W. Evans, D.Sc., LL.B., F.G.S., and R. W. Pocock, B.Sc., F.G.S.

THE discovery by Professor Reynolds in the Mendips strata representing the greater portion of the Silurian succession (Rep. Brit. Assoc. Portsmouth, 1911), showing no similarity to the slates of Mortehoe and the neighbourhood, has rendered it more difficult than ever to accept the attribution by Dr. Hicks of the latter rocks to the Silurian period (Q.J.G.S., vol. lii, p. 254, 1896); and now an important fact has come to light which appears to afford decisive evidence on this question.

Mr. J. G. Hamling, whose valuable contributions to our knowledge of the rocks of North Devon are well known, recently entrusted the authors, who are now working at the Morte Slates, with some exceptionally well-preserved specimens of fossils from Barricane Beach, on the Mortehoe side of Woolacombe, which were included in the exhibits of the Geologists' Association at the Shepherd's Bush Exhibition. Among these are examples of a *Spirifer*, evidently identical with *Sp. Hamlingi*, Hicks, from the same locality but in a better state of preservation than the type, judging by the figure in Dr. Hicks' paper; the authors have been unable to trace the original.

Mr. Hamling states that the new specimens, which are embedded in a matrix of yellowish grit, were found beside the path down to Barricane Beach. They were not actually in situ when discovered, but he has no doubt that they came from a small section close by, which was opened to obtain material to mend the path shortly before he visited the spot. The exact locality is three or four yards up the path from the beach on the left when ascending. He spent some time trying to find the grit in situ, but without success, and believes that it occurs in lenticles, and that the workmen dug out the whole of this particular lenticle, which was probably of no great length. The material employed on the path exactly matched that which remained in the newly excavated section, and nothing was brought from elsewhere. Dr. Hicks obtained his specimen of the *Spirifer* from the same place, but a little further down. It may be added that one of the fragments in which the fossils are embedded shows on one side

a distinctly slaty facies, which presents a close resemblance to the normal Morte Slates of this area.

Spirifer Hamlingi must be classed with the 'aperturati' group of the genus and is undoubtedly a varietal form of *Sp. Verneuili*, Murch. (=*disjunctus*, Sow.). The fold and sinus are distinctly marked off from the side portions of each valve, and the sinus is narrower and deeper than it is in other varieties of the species. The number of the plications in the fold and sinus is about twelve. The valves are not distinctly winged, and the ratio of the breadth to the length is approximately four to three, the former measuring in the larger specimen a little more than 22 mm. and the latter nearly 17 mm. These figures may, however, be somewhat modified when the matrix is cleared from the specimen.

Closely similar but somewhat larger specimens in the British Museum (Natural History) are labelled "near Taunton". They are in a reddish-yellow grit, and were, Mr. Ussher believes, those described by the Rev. W. Downes (Trans. Devon. Assoc., 1881, pp. 293–7), which were found in New Red gravels at Bolham, and may have been derived from the Pilton Beds which outcrop to the northward. Gosselet figures a somewhat narrower form from the Schistes de Senzeilles (zone of *Rhynchonella Omaliusi*) at the base of the Famennian (Mém. Soc. Géol. Nord, vol. iv, pt. i, p. 30 and fig. 38, 1894), and a variety figured by G. and F. Sandberger under the name of *Sp. calcaratus* (Sow.) (Verstein. rhein. Schicht. Wiesbaden, 1850–6, pl. xxxi, figs. 10, 10*a*–10*c*) also presents many points of similarity. It may be added that no representatives of the species are found on the Continent lower than the passage beds between the Middle and Upper Devonian.

On one of the slabs there are also specimens of a *Rhynchonella*, which is probably identical with the form obtained by Hicks from the same locality and identified by him as *Rh. Lewisi*, Dav. They appear to resemble *Rh.* (*Camarotoechia*) *ferquensis*, Gosselet, from the Lower Frasnian of Belgium and the Boulonnais, and *Rh. letiensis*, Gosselet, from the Upper Famennian, two closely allied forms which were formerly included in *Rh. pleurodon*, Phil., into which the latter is believed by Gosselet to pass at the commencement of the Carboniferous period (Ann. Soc. Géol. Nord, vol. xiv, pp. 199 and 206, 1887).

There is therefore a prima facie case for placing the Morte Slates of Barricane Beach in the Upper Devonian and for regarding the apparent succession of the rocks on the coast of North Devon as the true one. At the same time it must be admitted that whenever the southern margin of the Morte Slates in North Devon has been examined there appears to be evidence of disturbance which renders it possible that there has been considerable dislocation of the strata along this line. This is, however, only what usually occurs at the junction of rocks which differ considerably in their physical characters in an area which has been subjected to powerful earth-movements, and does not imply that the faulting which may have taken place represents a large relative movement of the beds, and in the Marine Drive at Woolacombe there appears to be distinct evidence of a transition

between the slates and the arenaceous Pickwell Down Beds, though the relations of the rocks are somewhat obscured by the surface-slipping that has taken place.

There is reason to believe that not only the Morte Slates but also a considerable portion of the Ilfracombe Beds belong to the Upper and not the Middle Devonian, with which they are usually classed. For *Stringocephalus Burtini*, Defr., which marks the highest horizon in the Middle Devonian, appears to occur near the base of the Ilfracombe Series in the Combe Martin Beds, and *Calceola sandalina*, Linné, which is the characteristic fossil of the Lower Middle Devonian, is wholly wanting, while a variety of *Spirifer Verneuili* is found in a quarry above Rillage Point, which should be comparatively low down in the Ilfracombe Beds, and *Rhynchonella cuboides*, Sow., which, like *Spirifer Verneuili*, is not found below the passage beds on the Continent, is also met with. Through the kindness of Professor McKenny Hughes, Dr. Evans had had an opportunity of seeing a well-preserved specimen of *Spirifer Verneuili* from Caple Pit, near Ilfracombe, which is believed to represent the same horizon.

The ascription of the Morte Slates to the Upper Devonian is not new. As early as 1889 they were placed by Mr. Ussher partly in the Middle and partly in the Upper Devonian (Rep. Brit. Assoc., 1889, p. 801), and in the same year Professor Kayser compared them with the Frasnian (Neu. Jahrb. für Min., etc., vol. i, p. 181, 1889).

The conclusions to which the authors have come with regard to the age of the slates of Barricane Beach do not necessarily apply to the rocks which have been included under the same name in Western Somerset. So far as their work has proceeded in that area it shows that the beds vary considerably in character, and are probably, as Dr. Hicks suggested (Q.J.G.S., vol. liii, p. 438, 1897), of very different ages; though whether they can be assigned to the horizons to which they were referred by him and Mr. Whidborne is a point on which the authors must for the present refrain from expressing an opinion.

It may be added that Mr. Ussher, who has done a considerable amount of work in West Somerset which has never been published, has volunteered to co-operate with them in that area.

VI.—On the Occurrence of Submerged Forests in certain Inland Lakes in Donegal.

By W. B. Wright, B.A., F.G.S., Geological Survey of Ireland.

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FOR many years past the Swedish geologists have been directing the attention of the scientific world to the curious phenomenon of the occurrence of submerged forests in certain of their inland lakes.[1] In our own country such evidences of change of level are a familiar sight along our sea-coasts, and, if we bear in mind the extreme

[1] Rutger Sernander, "Om förekomsten af subfossila stubbar på Svenska insjöars botten": Bot. Not., 1890. German translation in Bot. Centralbl., Cassel. Bd. xlv, 1891.

Arel Gavelin, "Studier öfver de postglaciala nivå- och klimatförändringarna

instability of the sea-level, their presence is little to be wondered at. In all bodies of water which have no outlet—and the sea is only the largest of these—the surface-level is determined by the balance between supply and evaporation, and oscillation is inevitable. In the case of freshwater lakes, however, the level is determined within small limits by the overflow, and the occurrence of tree stumps in the position of growth beneath their waters presents therefore a problem of considerable interest.

The Swedish cases already described may be classified under three heads—

(1) Trees which have become submerged owing to the transgression of the waters at one side of the lake as a consequence of the post-glacial tilting of the country.

(2) Trees which are submerged in lakes the outlet of which is through a marsh or peat moss. These cases admit of a simple explanation through choking up and raising of the outlet by the growth of vegetation.

(3) Cases where the outlet is over rock or drift, in which there is either no tilting, or the tilting is towards the outlet, or towards the opposite shore from that on which the submerged trees occur.

Several examples of class 3 have been discovered, and it is these which have a more special interest for us, for they are held by certain of the Swedish geologists to be capable of only one explanation, namely, that the lake during some period of its history was without outlet, and either entirely dried up or was considerably below its normal level.

Now in Ireland cases referable to class 2 are not uncommon,[1] but I am not aware of any case having, up to the present, been either described or observed which is without question referable to class 3.

In the summer of 1910, however, while engaged in geological mapping in the mountain and moorland district north-west of Pettigo, Co. Donegal, I came across several cases of this nature, having made a systematic search for evidence of change of level along the shores of all the lakes in the district. An area of 22 square miles of moorland was examined, and this was found to contain twenty-six small lakes. In seven of these submerged stumps of fir-trees can

på norra delen af det Småländska höglandet": Sveriges. Geol. Unders., ser. C, No. 204 (= Årsbok i, No. 1), 1907.

Rutger Sernander, "Hornborgasjöns nivåförändringar": Geol. Fören. i Stockholm Förh., Bd. xxx, p. 70, 1908.

—— "Hornborgasjöns nivåförändringar och våra högmossars bildningssätt": ibid., Bd. xxxi, 1909.

—— "Sjön Hedervikens vegetation och utveklings historia": Sv. Bot. Tidskr., Stockholm, Bd. iv, 1910.

L. von Post, "Skarbysjö-komplexet och dess dräneringsområdes postglaciala utvekling": Geol. Fören. i Stockholm Förh., Bd. xxxi, 1909.

Rutger Sernander, "Die schwedischen Torfmoore als Zeugen postglazialer Klimaschwankungen." *Die Veränderungen des Klimas*: Geol. Congress, Stockholm, 1911, p. 197.

Gunnar Andersson, "Swedish Climate in the Late Quaternary Period": ibid., p. 247.

[1] There is a submerged forest in Loch Fada in the Island of Colonsay, off the west coast of Scotland, to which attention was first called by Symington Grieve. The outlet of this lake is, however, through a peat moss; see W. B. Wright and E. B. Bailey, *Geology of Colonsay and Oronsay* (Mem. Geol. Surv. Great Britain, 1911).

be seen in the position of growth, but in three of the cases the outlet of the lake is through a peat-bog, so that no conclusion regarding the failure of the outflow during the growth of the trees could be based on them. In the remaining four (Loughs Bannus, Avehy, Drumgun, and Afurnagh) the outlet is over rock or boulder-clay, but the last-named is open to exception, as it is extensively margined by peat, through which it may possibly at one time have had a lower drainage.

Lough Bannus is situated on the Donegal Road, 2 miles W.S.W. of Pettigo. Its surroundings are shown in Fig. 1. It lies among drumlins, and has its outflow to the east over boulder-clay, the stream, however, soon entering a little rocky valley without any great fall. The outlet has been lowered by artificial cutting to the extent of about two feet, and there is an abandoned shore-line about the same

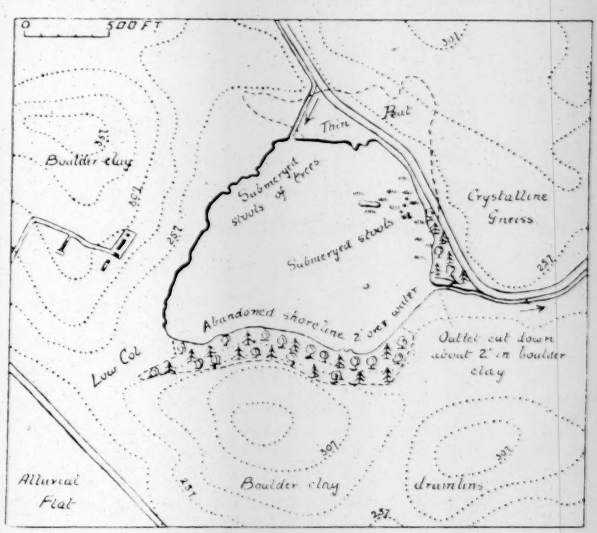

FIG. 1. Map of Bannus Lough, showing the position of the submerged tree stumps and the contours of the surrounding ground.

height above the water surface round the south side of the lake. It is clear, therefore, that in its natural state the lake was some two feet or so higher than at present. Tree stumps, submerged even at the present day, have been observed in two places, one on the northern shore and one on the eastern. The latter appear to be in the position of growth, the former are more doubtfully so.

Lough Avehy (Fig. 2) is on the Ballintra Road, $4\frac{1}{2}$ miles west of Pettigo. Its southern and western shores are formed of boulder-clay, and its northern and eastern of crystalline schists. It has cut fairly steep scarps, five or ten feet high, in the boulder-clay on the south side; but these are no longer being eroded, for the level of the lake has been lowered from two to three feet, apparently by artificial drainage, and there is an abandoned shore-line at about

that height as in Lough Bannus. The outlet is to the east over rock debris and drift, the stream descending rapidly into a little rock gorge. The submerged tree stumps, which are obviously in the position of growth, occur in two places in a bay to the north-east of the lake. They are beneath the level of the water even at the present day.[1]

Drumgun Lough is a mile and a half due west of Pettigo. It is surrounded for the most part by boulder-clay, but rock appears on the shores in several places. The outlet is to the south between boulder-clay and rock. There is a fairly large peat moss bordering the lake at the east end, and a small one at the west end. Tree stumps are visible in the water on the northern shore, but it is possible

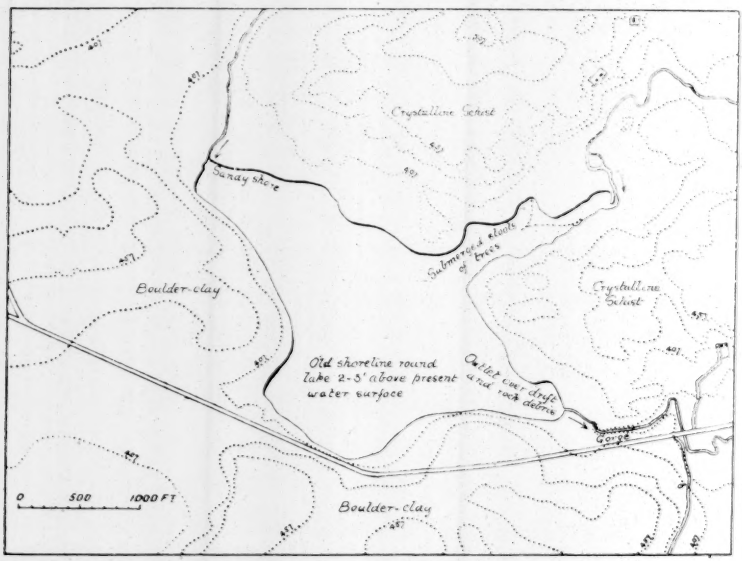

FIG. 2. Map of Lough Aveby, on the scale of 3 inches to a mile, showing the position of the submerged tree stumps and the contours of the surrounding ground.

that they are not in the position of growth. They are also to be seen on the eastern shore, where the lake at one spot is cutting away the bog. It is not clear in this position either that the submerged stools are in place. This is, however, a good locality for cutting a section in the peat, if it should ever be desired to determine the relations more exactly.

Lough Afurnagh lies on the moorland about two and a half miles W. 30 N. from Pettigo. It is surrounded on all sides by crystalline schists and peat mosses. It has its outlet to the west over a ledge of rock, but the shore for about a hundred yards to the north of the

[1] In the case of excavations ever being made with a view to further investigating the oscillations of level and the sequence of plant growth, I would suggest the sandy shore in the north-west bay of this lake as a suitable place.

outlet is formed of thick peat, which connects with the outflowing stream lower down, so that it is impossible to prove that the outlet has not shifted. This lake contains some of the most beautiful examples of submerged fir stools in the position of growth on both its northern and southern shores. It is in many places cutting away the peat at its margins, and exposing more stools both below and above the present water-level.

The remaining lakes which contain fir stools are Ultan, Aguse Mor, and Navarnan.

Lough Ultan lies on the crystalline schists about three miles north-west of Pettigo and north of the Donegal Road. There is a good deal of deep bog round it, and the outlet is through peat. At the south end of the lake there are some large submerged tree stumps in the position of growth, and also several in the middle of the western shore.

Lough Aguse Mor is near the Black Gap, to the south of the Donegal Road, 5 miles W.N.W. of Pettigo. It is surrounded almost entirely by bog, and has a sluggish outlet to the south through a level swamp. Fine examples of submerged tree-roots in the position of growth occur all round its northern and eastern shores, there being one magnificent fir stool, 9 feet in diameter, on the eastern shore.

Lough Navarnan is about a mile north-west of Drumgun Lough. The outlet is to the south through a peat moss. It has evidently been lowered by artificial cutting, for there is an abandoned shore-line round the lake about two feet or so above the highest floods of the present day. Submerged tree stumps can be seen at the north end of the lake.

Now although it is exceedingly probable that the submergence of the trees in all these lakes is due to the same cause, yet in any argument based on the facts here presented we are bound to put four of them aside, because it is impossible to prove that they had not lower outlets before the growth of the present peat-bogs. These four are Afurnagh, Ultan, Aguse Mor, and Navarnan. Drumgun is unconvincing for another reason—the submerged stumps in it are not demonstrably in the position of growth. There remain to us Loughs Bannus and Avehy. In these cases we are dealing with trees which grew below the present level of the outlet, and it is necessary in the next place to consider whether the outlet could not have been raised by tilting since the growth of the forest. One can suppose a special tilt for each lake, or a general tilting over a large area. Against the first supposition it is difficult to produce any argument, and it is certainly open to those who prefer such a hypothesis to adopt it as an explanation of this peculiar phenomenon. There is, however, a complete absence of any evidence of post-glacial folding or faulting in Ireland. Indeed, there is distinct evidence against it in the southern half of Ireland in the presence of a pre-glacial shore-line at a uniform level all round the coast. This shore-line has, however, not been traced into the north of Ireland, where the lakes under discussion are situated.

The hypothesis of a general warping or tilting of the country is much more plausible, because in the north and east of Ireland a deformation of this nature has been proved to have affected the

Campignien or Early Neolithic Beach. This proved warping, however, has a magnitude of only an inch or two in the mile, and is moreover in the wrong direction to serve as an explanation of the submergence on the shores of Loughs Bannus and Avehy. The smallest tilt that would cover the observed facts should amount to about 50 feet to the mile in the case of Bannus and 20 feet to the mile in the case of Avehy. If such an enormous movement as this has affected the district in general it ought to show itself on the sea-coast, unless indeed the shore-line of the forest period now lies so far beneath the sea that the tilting nowhere brings it above the surface. It is clear that an explanation based on tilting would strain our conceptions of post-glacial warping to the utmost.

There remains the explanation adopted by certain Swedish geologists to account for the same phenomenon in their own country. This is that the lakes during the growth of the forests had no overflow and sank beneath the level of their outlets. They ascribe this to the relatively dry climatic conditions which they suppose facilitated the growth of forest instead of bog. It is impossible to discuss here the merits of the climatic theory of the peat-bog succession, but it seems reasonable to assume that, if the Swedish cases are due to a period of dry climate, the Irish cases are to be explained in the same way.

Personally I do not feel at all certain that the mere existence of dense forests over the catchment area of these small lakes might not reduce the amount of water brought in by the tributary streams to such an extent as to lower the level of the lake, or even dry it up altogether except during exceptional floods. If, however, future advances in the study of the economy of forests should prove this idea to be untenable, there would seem to be but small chance of escape from the hypothesis of a very considerable change in the climatic conditions of the regions in which these submerged forests are found.

VII.—The Late Palæozoic Alkaline Igneous Rocks of the West of Scotland.

By G. W. Tyrrell, A.R.C.Sc., F.G.S., Assistant to the Professor of Geology, Glasgow University.

(*Concluded from the February Number, p. 80.*)

2. Essexite. (a) *Carskeoch type.*—A small boss of essexite, of rather basic type, pierces the agglomerate of the Carskeoch vent, near Patna, Ayrshire. Macroscopically it is light grey, compact, and fine-grained. In thin section it shows a plexus of fluxionally-arranged plagioclase laths of the composition Ab_1 An_1, the interstices being filled with subhedral augite of a nearly colourless variety, and fresh olivine. Here and there minute angular interspaces are occupied with turbid isotropic matter, the form and arrangement of the particles of which suggest the former presence of nepheline. A few broad plates of pale augite and crystals of olivine interrupt the general trachytoid fabric. Ilmenite and biotite occur sparsely, and a little orthoclase may be detected on the margins of the plagioclases, extending irregularly into the interspaces. This rock has a distinct individuality,

and resembles neither the essexites of Lochend and Craigleith in the Lothians, nor the Crawfordjohn type described below. It is poor in alkali-felspars and felspathoids, is devoid of purple augite, and has a well-developed trachytoid fabric.

(b) *Crawfordjohn type.*—This type, which was first described by Teall, is named after the famous locality for curling stones in South Lanarkshire. The type-rock apparently comes from one of the long north-west–south-east dykes which are believed to be of Tertiary age. It is, however, so exactly identical with rocks from Lennoxtown and Patna, and so incongruous with the Tertiary suite that there seems no alternative than to regard the rock as belonging to the Late Palæozoic alkaline types. The Lennoxtown occurrence forms a massive irregular dyke intrusive in Calciferous Sandstone lavas on the southern slopes of the Campsie Hills; the Patna occurrence is a small boss intruding the agglomerate of the Late Palæozoic vent of Carclout Hill, and therefore establishes the age of this type. The latter occurrence is congruous with the presence of alkaline intrusions in other vents of the same district, and the Late Palæozoic age of the entire suite seems to be well established.

As the Crawfordjohn and Lennoxtown rocks have been previously described by Allport, Teall, and Bailey, only the new occurrence at Patna falls to be described here. In hand-specimens it is greyish, compact, fine-grained, carrying numerous lustrous black phenocrysts of augite. Microscopically it is composed of a plexus of broad laths of plagioclase (Ab_1 An_1), which are idiomorphic to abundant and often beautifully fresh nepheline. Limpid analcite occupies some of the interspaces and encloses the euhedral terminations of felspar laths. Titano-magnetite is aggregated into groups of euhedral crystals associated with flakes of biotite. In the above, as groundmass, numerous large phenocrysts of deep purple titanaugite and fresh olivine are set. The pyroxene moulds and encloses olivine, and occasionally also the terminations of the felspars. In size it ranges up to half an inch in diameter. The olivine rules much smaller, and should perhaps be associated descriptively with the groundmass. Apatite occurs in great abundance enclosed in nepheline and analcite. Nepheline occurs in the Lennoxtown and Crawfordjohn rocks, as described by Lacroix,[1] and Bailey.[2] It is sometimes, as in the Patna rock, so abundant as to make it a question whether the rock should not be described as a theralite. Mr. Bailey, however, has placed the Lennoxtown occurrence in the essexite family on account of its very close resemblance to Brogger's essexite from Brandberget, Christiania district.[2]

3. Kylite.—This well-individualized type occurs as a homogeneous and abundant set of sills and bosses in the Kyle district of Ayrshire, from whence it derives its name. It is an olivine-rich ultra-femic theralite or essexite. The chemical and mineralogical composition is quite distinctive; and as the rock is not a mere differentiation-facies of theralite or essexite, but forms numerous independent sills, it has been thought advisable to mark its individuality by giving it a new name.

[1] *Compte Rendu*, cxxx, 1900, p. 1273.

[2] Bailey, loc. cit.

The massive sill of Benbeoch, near Dalmellington, is taken as the type-occurrence. Macroscopically the rock is compact, fresh, phanerocrystalline, and rather fine-grained. The dominant tint is grey or greenish grey, the latter when olivine is very abundant. In thin section the rock is composed of dominant olivine in fresh rounded crystals, and titanaugite forming large anhedral to subhedral plates and prisms much indented by the terminations of laths of labradorite. Many small rounded grains of olivine and some of ilmenite are poikilitically enclosed in the augite. Labradorite and subordinate nepheline form a kind of groundmass to the somewhat larger-sized ferro-magnesian constituents, which tend to form polysomatic groups, and thus take on a pseudo-porphyritic aspect. Some later felspars are zonal and range in composition from $Ab_4\ An_3$ to $Ab_5\ An_3$. Orthoclase may be detected on careful examination, bordering the lime-soda felspar. The nepheline is somewhat decomposed, but is recognized by the usual distinctive characters (p. 79). A little clear analcite was the last constituent to crystallize. The only other minerals seen are skeletal ilmenite associated with scraps of reddish biotite, and a little apatite. The general fabric is evenly granular. The rock has been analysed by Dr. Dittrich, of Heidelberg, with the result given in column I, Table IV below. Four other analyses are tabulated for comparison.

TABLE IV.

	I.	II.	III.	IV.	V.
SiO_2	44·18	42·87	48·57	40·32	44·42
TiO_2	1·30	—	1·48	2·66	1·63
Al_2O_3	10·67	10·93	10·51	9·46	13·33
Fe_2O_3	·97	3·44	2·19	4·75	9·14
FeO	10·03	10·14	9·45	7·48	6·35
MnO	—	trace	·16	·25	—
MgO	17·77	16·27	17·53	18·12	5·74
CaO	9·75	9·11	8·06	10·55	10·60
Na_2O	2·37	·92	1·59	2·62	5·60
K_2O	1·23	·13	·34	1·10	1·81
$H_2O -$	·97	·57	·10	·57	1·75
$H_2O +$		2·87	·37	1·25	
P_2O_5	·38	trace	·19	·68	·35
CO_2	trace	trace	none	—	—
S	—	—	—	·01	·18
NiO, Cr_2O_3, etc.	—	—	·18	·27	—
	99·83	99·95	100·72	100·09	100·35
Sp. gr.	3·05	—	3·065	3·148	—

I. Kylite, Benbeoch, Dalmellington.
II. Hornblende-picrite, Ty Croes, Anglesey. Bonney, Q.J.G.S., vol. xxxix, p. 256, 1883.
III. Ultra-femic olivine-basalt, lava-flow of 1852, Mauna Loa, Hawaii. Daly, *Journ. Geol.*, vol. xix, p. 296, 1911.
IV. Nepheline-basalt, Uvalde County, Texas. Cross, Bull. U.S. Geol. Surv., No. 168, 1900, p. 62.
V. Theralite, Flurhubl, Duppau, Bohemia. F. Bauer, T.M.P.M., vol. xxii, p. 281, 1903.

The Benbeoch analysis is remarkable for low alumina, very high magnesia, ferrous iron, and lime, combined with comparatively high alkalies. It does not correspond exactly with any known analysis. Its nearest affinity is the ultra-femic nepheline-basalt of Uvalde County, Texas. Analyses II and III correspond fairly well with it in all except the alkalies, which are much lower than in the Benbeoch rock. This is accounted for by the absence of felspathoids in these rocks. Compared with a typical theralite the kylite analysis shows a considerable diminution in alumina and alkalies, but contains almost three times as much magnesia for about the same silica percentage. Kylite therefore appears to fall into place as the plutonic equivalent of an ultra-femic nepheline-basalt.

The quantitative mineral composition, as estimated by the Rosiwal method, is given in column I, Table V below, together with mineral analyses of the principal variations of the rock. The labradorite in each case includes a little orthoclase, perhaps 2 or 3 per cent.

TABLE V.

	I.	II.	III.	IV.
Labradorite . .	26·8	33·1	32·3	17·0
Nepheline . . .	3·8	2·3	6·1	—
Analcite . . .	1·8	·6	1·4	4·7 [1]
Titanaugite . .	25·1	27·6	25·9	19·7
Olivine . . .	37·8	29·5	27·9	55·4
Ilmenite . . .	2·1	4·4	4·3	2·5
Biotite	2·0	1·8	1·4	—
Apatite . . .	·6	·7	·7	·7

I. Kylite, Benbeoch, the dominant type, analysed by Dr. Dittrich.
II. Kylite, a less femic facies, Benbraniachan.
III. Kylite, a less femic facies, Craigmark.
IV. Kylite-picrite, an ultra-basic facies, Chalmerston Hill, Benbeoch.

It will be noted that all these rocks are dofemic, to use a convenient term. Although the type represented by I forms at least three-quarters of the mass of Benbeoch, some distinct varieties, represented by II, III, and IV, must be recorded. II and III are satellitic outliers of the upper part of the Benbeoch sill, and are notably richer in the felspathic constituents and poorer in olivine. IV, on the other hand, forms an ultra-basic stratum at or a little below the centre of the sill. This facies consists principally of large euhedral to subhedral crystals of partially serpentinized olivine, forming 50–60 per cent of the rock. Large plates of titanaugite and fresh plagioclase form the major part of the remainder. Both minerals poikilitically enclose numerous small rounded olivines. The augite and felspar are idiomorphic towards a turbid base, partly identifiable as analcite and partly indeterminate, which encloses flakes of biotite and large cross-fractured crystals of apatite. The felspar plates show in unusual perfection the radiating fissures springing from enclosed olivine.

[1] This includes a little unidentified turbid matter.

This *couche* of ultra-basic rock in the centre of the Benbeoch sill appears to be susceptible of precisely the same explanation as that adopted for the similar phenomena of the Lugar complex (p. 76); and also for an olivinic ledge in the Palisade quartz-diabase sill of New Jersey.[1]

C. *Rocks without conspicuous Analcite or Nepheline.*

Associated with the more alkaline types described above are a great number of less alkaline rocks, which, however, betray their affinities by the abundance of purple augite and the occasional presence of an interstitial wedge of clear analcite. Some of them accompany the analcite-syenites apparently as differentiation-facies. Others form small masses intrusive in the highest horizons in the West of Scotland—the 'Permian' red sandstones and lavas of the Mauchline district. While rather variable in their characters it does not seem possible to divide them into well-characterized groups. The following description applies particularly to the sill in the Trabboch Burn, near Stair, Ayrshire, a fresh and typical example of these rocks which may serve as a type of the whole suite. It contains a few veins and irregular patches of analcite-syenite.

Megascopically the Trabboch Burn rock is greyish in colour, medium and even-grained, consisting essentially of grey felspar and black pyroxene in approximately equal proportions. In thin section the rock consists of a coarse-grained aggregate of broad laths of zonal plagioclase in subophitic relations with large subhedral to anhedral plates of purple titanaugite. Fresh olivine occurs in some quantity, and also ilmenite, the large skeletal aggregates of which are intergrown poikilitically with the pyroxene. It is associated, as usual in these rocks, with a few scraps of red biotite. A soda-bearing orthoclase may occur in some quantity, generally with analcite. The latter fills up interspaces and encloses the idiomorphic terminations of felspars, grains of augite, and needles of apatite. The proportions of orthoclase and analcite are very variable, and in some sections they are absent. The plagioclase is highly zonal, ranging in composition from Ab_1An_1 to Ab_1An_3, and has often suffered partial analcitization.

All the other rocks falling under this group have the same general aspect as the above. There is, however, considerable variation in the proportions of certain constituents. Analcite and orthoclase frequently fail, olivine often becomes an abundant constituent, whilst many of the rocks show a perfect ophitic structure.

These rocks are ophitic dolerites, which, whilst not conspicuously alkaline, show considerable affinity with the alkaline series. This may be appropriately recognized by terming them *alkali-dolerites*. Those varieties which contain analcite and soda-orthoclase belong to the essexite family, and their doleritic aspect may be recognized by the designation *essexite-dolerite*. They closely resemble the 'crinanites' of Argyllshire. (Mem. Geol. Surv., *Geology of Colonsay*. 1911.)

[1] J. V. Lewis, *Annual Report of State Geologist for 1907*: Geol. Surv. of New Jersey, 1908, p. 129.

The alkali-dolerites and essexite-dolerites are abundantly developed in the Dalmellington district. The chief localities are Muck Burn, Dalnean Hill, Dalcainnie Hill, Grimmet Glen, Whitehill (Patna), Polnessan Burn, Rankinston, Dunaskin Glen, and Ashbeugh Glen. In the district of which Tarbolton is the centre, the chief localities are Auchincruive, Helenton, Howford Bridge, Dippol Burn, Trabboch Burn, Stair, Failford, Auchinweet, and Barskimming.

The analcite-syenite differentiate is only found in the Mauchline–Tarbolton district; it has not been recognized in the Dalmellington area. In the latter, however, the alkali-dolerites sometimes contain pink acid veins, notably at Muck Burn, Dalmellington, and the Coyle Water, Rankinston. At the latter locality the veins consist of a medium-grained plexus of zonal plagioclase margined by orthoclase, associated with an approximately equal quantity of moiré and perthitic orthoclase in broad anhedral plates. A little granular pyroxene and skeletal ilmenite is enclosed in the felspars, also some biotite and chlorite; but the proportion of femic minerals is very small. This rock has affinities with the monzonites.

The Muck Burn variety is much finer in grain, and attains a vein-width of 5 inches. It consists of a fine-grained aggregate of well-shaped laths of orthoclase and acid oligoclase, the latter slightly predominating. The interstices are filled with quartz and cryptocrystalline matter. The only other constituent is a little leucoxene. The structure is typically orthophyric, and the rock might be termed a monzonitic orthophyre. If the orthoclase is soda-bearing, as is probably the case, the rock becomes a keratophyre.

D. *The Mauchline Lavas.*

These rocks occur in a narrow ring-shaped outcrop surrounding the 'Permian' red sandstones of the Mauchline–Tarbolton area. Their geological features have been described by Sir A. Geikie.[1] Their petrographical character is the subject of a brief note by Dr. Hatch in Sir A. Geikie's *Ancient Volcanoes*.[2] The picrite there described is probably one of the monchiquite or limburgite lavas. Mr. David Ferguson, who has devoted much attention to this district, estimates the thickness of the lavas at 280 feet. This thickness is made up by a number of thin flows intercalated with tuff and red sandstone. These intercalations increase in number and thickness towards the top of the lavas until they merge into the thick overlying sandstones. The lavas have been poured out from a series of small 'greenhill' vents situated mostly round the northern edge of the outcrop.[3] Numerous vents also occur round the margin of the high Carboniferous plateau to the north of Dalmellington, which was doubtless once covered by a cap of lavas. The vents contain lavaform material in blocks and apparently intrusive masses, which extend our knowledge of the petrography of this late series of Palæozoic lavas.

[1] Geol. Mag., Vol. III, p. 243, 1866.
[2] *Ancient Volcanoes of Great Britain*, vol. ii, p. 57, 1897.
[3] Tyrrell, "The Geology of Mauchline," in *The Land of Burns*, by J. T. Gibb, of Mauchline, 1911.

Megascopically the lavas are very uniform in appearance. They are all compact, aphanitic, varying in colour from dark red to purplish, rarely grey or black. A very characteristic aspect is imparted by a universal red speckling due to the replacement of microporphyritic olivines by red iron-ores derived from the overlying sandstones. A red stain of diffused iron-oxide frequently gives the rocks an appearance of decomposition which is belied by the general freshness apparent in thin section. Porphyritic olivine is invariably present, augite rarely, but felspar never. The above characters easily distinguish these rocks from the earlier Carboniferous lavas, and have been found very useful in determining the age of some doubtful vents.

The following minerals have been found in thin section: olivine, almost invariably pseudomorphed by hæmatite, purple titanaugite, plagioclase ($Ab_1\ An_1$–$Ab_2\ An_3$), analcite, nepheline, and sparse iron-ores.

The lavas can be broadly divided into two divisions characterized by the presence or absence of felspar. The felspathic group is the most abundant, and includes femic types of olivine-basalt (cf. Hillhouse and Dalmeny types), analcite-basanite, and analcite-nepheline-basanite. The two latter are probably to be classed with the Kidlaw basalt of the Lothians.[1] In the Dalmellington district the vents contain blocks comparable to mugearite and Markle basalt (a non-porphyritic variety). These, however, are extremely rare. The felspar-free rocks include monchiquite, analcite- and nepheline-basalt, and limburgite, types which are also represented in the Lothians.[2]

The *olivine-basalts* consist of abundant micro-porphyritic olivines, pseudomorphed by hæmatite and serpentine, in a groundmass made up of granular augite and lathy plagioclase, the former usually predominating. The minute interstices are occasionally filled with analcite or with turbid material resulting from its decomposition. Transitional types connect these with the *analcite-basanites*, in which analcite occurs in sufficient quantity to rank as an essential constituent. In a rock from the Thornton vent, near Kilmaurs, the analcite occurs as a fresh pellucid, pervading base, enclosing a plexus of augite granules and plagioclase laths. Olivine and a little augite occur as phenocrysts. In another type from Sorn Hill, near Catrine, the texture is doleritic, and the analcite occupies large polygonal cavities, usually bounded by laths of felspar. It contains detached granules of deep-purple augite, and envelops projecting felspars which appear to have suffered corrosion. Olivine is abundant as phenocrysts with the usual hæmatite replacement; also augite in abundant large polysomatic aggregates of a much paler tint than the augite of the groundmass. This rock also contains nodules of closely packed granules of augite with a little felspar, but no nucleus of analcite. These are comparable with the ocelli found in similar rocks in the Lothians.[3]

A few of these rocks contain nepheline. It is always associated with analcite, and both minerals may occur in a perfectly fresh

[1] *Geology of East Lothian*, 1910, pp. 106, 111.
[2] Ibid., pp. 106–7.
[3] Ibid., p. 109.

condition in the same interspace. A typical example of these rocks occur in a vent exposed in the River Irvine, near Hurlford. This consists predominatingly of anhedral grains of purple augite with a little magnetite in an apparently continuous colourless groundmass, which, in polarized light, breaks up into laths of plagioclase, isotropic analcite, and low-polarizing nepheline. Both the latter occur in interstitial areas in which the nepheline occupies the margins, and projects with good crystal form into more or less decomposed analcite occupying the central space. The nepheline has the characters of 'nepheline x', described by Bailey, and is accompanied by a mineral of much the same appearance but lower refractive index, just as in the East Lothian occurrences.[1] These rocks may be termed *analcite-nepheline-basanite*. With increasing abundance of nepheline and a corresponding diminution of analcite and felspar, especially the latter, these rocks approach closely to the true *nepheline-basalts*. A rock from the Alton Burn, Tarbolton, is generally similar to the above, but is much richer in nepheline. The latter forms small plates poikilitically enclosing granules of augite. Small flakes of biotite occur abundantly in the groundmass, as well as apatite in large stumpy crystals, averaging one-tenth of an inch in diameter.

The true *monchiquite lavas* are well represented by a beautifully fresh rock from the burn near Stevenston, two-thirds of a mile north-east of Ochiltree. It consists of a crowded mass of small euhedral grains of titanaugite and sparse minute specks of magnetite embedded in a scanty base of analcite. Olivine is very abundant in small porphyritic crystals, partly fresh, partly hæmatized. A few small phenocrysts of augite also occur. The analcite tends to segregate into small rounded areas which have tangentially aligned prisms of augite around their margins. In the larger areas the mineral shows anomalous double refraction similar to that of leucite, and the cubic cleavage is well marked. Other slides from the same locality show large ocelli of augite with a nucleus of analcite carrying detached aggregates of augite grains and numerous minute crystals of ægirine. The groundmass of this rock is largely composed of fresh nepheline which forms small plates poikilitically enclosing the other constituents. We have, therefore, the rare type *nepheline-monchiquite*.

Limburgite, characterized by a glassy base, is known from one locality only, the hardened rim of the little vent at the Earthwork, Barnweill, near Tarbolton. This mode of occurrence suggests that the glass in the rock is due to the refusion of original analcite in a monchiquite lava. The glass is distinguished from analcite by the lack of cleavage, its dark-brown colour, and by the abundance of microlites of magnetite. The presence of glass in place of analcite is the only difference between this rock and the monchiquite described above.

Petrology.

It is not possible here fully to discuss the petrology of these rocks considered as a homogeneous suite or province possessing certain characters in common, and otherwise bearing indications of a common

[1] *Geology of East Lothian*, 1910, p. 110.

origin. The material is deficient especially as regards the chemical analyses which are so vital to such a discussion. Nevertheless it is possible to indicate broadly the salient characters of the suite.

Geological occurrence.—The rocks occur as sills, small lenticular intrusive masses, volcanic plugs, and as a series of lava-flows. No occurrence of true abyssal habit is known. The intrusions are on a comparatively small scale, and range from occurrences, the outcrops of which cover only a few hundred square yards, to some, such as those of Craigie and Dundonald, which cover several square miles, and have a thickness of over 100 feet. Many are lenticular in form; others, however, are stratiform, and have a horizontal extension which is very great as compared with their thickness. This form frequently characterizes the sills rich in analcite, the original magma of which must have possessed unusual liquidity. A concomitant effect is a marked differentiation, which is usually best developed in sills, such as that of Lugar, having a wide horizontal extension.

The volcanic plugs may consist merely of lavaform material; but kylite, teschenite, and other rocks have also been found with this mode of occurrence. At Carskeoch Hill, near Patna, the agglomerate is pierced by a very heterogeneous complex (p. 120). The lavas occur in thin impersistent flows. The 280 feet of thickness estimated by Mr. Ferguson includes a large number of intercalations of tuff and sandstone. The lavas have been poured out from several 'greenhill' vents, characterized by their bright-green vegetation and sharply conical form. A thin skin of lava is occasionally found adhering to the walls of an agglomerate vent.

The sieve-like perforation of the sedimentary rocks by these vents is reminiscent of the Mid-Miocene vulcanicity of the Suabian Alb, as remarked by Daly. It is noteworthy that Daly has adduced the Ayrshire and Fifeshire districts as examples of secondary vulcanism, due to the opening of vents above satellitic intrusions. He remarks: "The steady association of tuff-neck and sill in the Scottish shires scarcely looks accidental."[1]

A remarkable absence of dykes belonging to this suite is to be noted. The only one known to the writer is a thick dyke-like mass of theralite (Bellow type) crossing the Lugar Water just below the Lugar sill. This is probably connected underground with the theralite of the Lugar sill. The Crawfordjohn dyke is a doubtful example and requires further investigation.

Chemical and Mineralogical Characters.—The chemical characters of the suite cannot as yet be adequately discussed. The chief points to be noted are that the magmas generally are poor in silica and rich in alkalies, especially soda, which is always in excess of potash.

The characteristic mineral of the suite is analcite. It occurs in almost every member, sometimes in large quantity, and in such relations to the other constituents as to establish indubitably its primary character. Indeed, this suite should go far to demonstrate the existence of an analcite series of igneous rocks parallel to those

[1] R. A. Daly, "Nature of Volcanic Action": Proc. Amer. Acad. Arts and Sciences, vol. xlvii, pp. 117–18, 1911.

characterized respectively by nepheline and leucite. Nepheline is of comparatively rare occurrence. There is abundant evidence in these rocks that it can be formed along with primary analcite. The dominant felspar is labradorite of the composition $Ab_1 An_1$; orthoclase (a soda-bearing variety or sometimes anorthoclase) occurs in very subordinate quantity.

The characteristic ferro-magnesian mineral is a pleochroic augite of a peculiar deep purple-madder tint, which is generally held to indicate a high titanium and soda content. Olivine is very abundant, and a peculiar red barkevicitic hornblende is occasionally present in some quantity. Ægirine and arfvedsonite appear in the more acid rocks.

The suite has a general basic character. Amongst the intrusive rocks teschenite is by far the most abundant. It shows a decided tendency to pass over to ultra-basic modifications. Subacid rocks are very rare in comparison, and acid rocks are unknown. The lavas are basic, with a large number of types verging on the ultra-basic. The abundance of analcite indicates a parent-magma rich in water and alkalies. Other volatile substances were probably present which are not now represented among the constituents of the rocks. Apatite, however, is very abundant, and seems always to be associated with analcite or alkali-felspars. Hence it is probable that fluxes like fluorine or chlorine were present in the magma. Whatever fluxes were present, there is evidence to show that the magmas were usually very liquid; and to that liquidity must be ascribed the very complete differentiation seen in some of the intrusions. The liquidity in some cases was so great that differentiation was controlled more by simple gravity-stratification than by differences of temperature set up during intrusion. This remark applies to differentiation after intrusion; but assuming a single original magma-reservoir, there can be little doubt that some differentiation took place before intrusion, as is evidenced by the variety of rocks which constitute the suite.

Distribution and Age.

The areal distribution of the various types seems to have some significance. The teschenites are the most widely spread types. They are mostly intrusive in the Carboniferous Limestone Series in the areas remote from the central volcanic districts of Mauchline and Dalmellington. Thus they are common in North Ayrshire and in the Cumnock districts. The Glasgow teschenites are separated from the nearest Ayrshire occurrences by a wide interval, which is mainly occupied by a great mass of calciferous sandstone volcanics. If they are connected with the Ayrshire centre it is remarkable that no teschenites are to be found in the intervening area; unless it is that these rocks found the calciferous sandstone lavas difficult of penetration.

The principal teschenite-picrite masses are ranged on the margin of the Coal-measure area surrounding the central volcanic district, as at Cumnock, Lugar, and Patna. The kylites penetrate the Coal-measures in the zone immediately surrounding the 'Permian' lavas of Mauchline, and are mostly concentrated in the southern part of that zone. The essexite-dolerites and analcite-syenites intrude the lavas and overlying sandstones of the Mauchline area; and a zone of

alkali-dolerite also occurs around the margin of the Coal-measure area of Dalmellington.

Despite minor irregularities, therefore, there appears to be a well-marked concentric distribution of the various types, in interrupted zones, with reference to the central volcanic area of Mauchline. Although the point needs confirmation by chemical analysis, it is probable that the Mauchline lavas are the effusive equivalent of the kylites rather than any other group.

This distribution provides a clue, not only to the relative ages of the main types, but also to the age of the suite considered as a whole. It is obviously distributed in relation to the lavas of the Mauchline tract, which overlie the Upper Red Sandstones of the Carboniferous, and are believed to be of Permian age. The widespread teschenites may represent the assumed parent-magma or one of the first differentiates from that magma. They were intruded into the lower levels of the adjacent strata, and were probably prior to the effusive phase. The highest horizon cut by them is the Coal-measures in the east of Glasgow. Here they are much faulted, and are without doubt of Late Carboniferous age.[1] The kylites, alkali-dolerites, and analcite-syenites may then be secondary or tertiary differentiates derived from subsidiary magma-basins intruded into the higher sedimentary levels at a later date, and accompanied by an effusive phase which gave rise to the Mauchline lavas.

The suite may therefore be assigned with much probability to the close of the Carboniferous period. Possibly the later members belong to the succeeding Permian. The Mauchline lavas have been assigned to the Permian by Sir A. Geikie.[2] Some doubt, however, attaches to the correlation, and there is some probability for the view that the red sandstones which overlie the Mauchline lavas are merely the upper part of the barren red sandstones of the Coal-measures, the two portions being separated by a volcanic episode.[3]

An allied suite of alkaline rocks has recently been described from the Lothians. These are intruded into the sediments above the Calciferous Sandstone lavas, and are thus clearly subsequent to this effusive period. The great majority intrude the Carboniferous Limestone Series. These later basic analcite-bearing rocks are said to bear a great resemblance to some of the lavas of Burntisland and Bathgate, belonging to the Carboniferous Limestone Series.[4]

It still seems questionable, however, whether some of the alkaline intrusions of the Lothians and Fife may not be linked on ultimately with a later volcanic episode than that of the Calciferous Sandstone or the Carboniferous Limestone. The famous 'Permian' volcanic vents of the Fifeshire coast, so well described by Sir A. Geikie,[5] are doubtless contemporaneous with the volcanic episode of the Mauchline district. The lavaform products have a striking similarity, although so far as is yet known, nepheline-bearing rocks have not been met with in the

[1] Mem. Geol. Surv., *The Geology of the Glasgow District*, 1911, p. 112.
[2] *Ancient Volcanoes of Great Britain*, vol. ii, p. 55, 1897.
[3] Tyrrell, Trans. Glasgow Geol. Soc., vol. xiii, pt. iii, p. 314, 1909.
[4] Mem. Geol. Surv., *Geology of East Lothian*, 1910, p. 104.
[5] Ibid., *Geology of East Fife*, 1902.

Fifeshire vents. It may well be, however, that on a thorough examination of material in these vents, a fuller correspondence may be established, in both intrusive and extrusive types, with the Ayrshire district. It is possible, therefore, that just as the intrusive alkaline rocks of the west are related to the Mauchline volcanic episode, so the similar rocks of Fife and the Lothians may be related to the latest ('Permian') volcanic episode of that district.

The fact emerges that the distinctively alkaline phase, at least as regards the intrusive types, began earlier in the Lothians than in the West of Scotland. In the former area the alkaline intrusions date from the Carboniferous Limestone; in the latter from the Coal-measures. The western suite as a whole was a little later than the eastern, and links itself definitely with a late Carboniferous or Permian volcanic episode; whilst the eastern suite appears to bridge the gap between the Calciferous Sandstone lavas and the 'Permian' volcanic episode of Fife.

Considered in relation to the homogeneous mass of alkaline types erupted during the Carboniferous period in the Midland Valley of Scotland, the western suite falls into place—recognizing the time element in petrographical provinces—as a sub-province and sub-period of the Carboniferous period-province of Central Scotland. Excluding the Glasgow teschenites, the boundaries of the sub-province are well defined to the north by the great mass of Calciferous Sandstone volcanics occupying North Ayrshire and Renfrewshire. These rocks, with Old Red Sandstone, also bound the area to the east. On the south and south-west the great Southern Upland marginal fault forms the natural boundary. To the west, however, the extension of the sub-province is indefinite. Some part may be faulted down beneath the Firth of Clyde. It extends at least as far as the Lady Isle, a teschenite mass in the Firth, 3 miles west of Troon; and may also include Arran and Bute. The Glasgow teschenites, as before stated, are remote from the Ayrshire district, and are possibly outlying members of the Lothians sub-province. It may be said that the western sub-province is approximately co-extensive with the county of Ayrshire, and that its time-boundaries are Coal-measures to Early Permian.

REVIEWS.

I.—Geological Survey Memoirs.

On the Mesozoic Rocks in some of the Coal Explorations in Kent. By G. W. Lamplugh, F.R.S., and F. L. Kitchin, M.A., Ph.D. 8vo; pp. vi, 212, with 5 plates and 5 text-illustrations. 1911. Price 3*s.* 6*d.*

IT is well that the Geological Survey has been able to rescue from oblivion a most important series of data, stratigraphical and palæontological, that have been disclosed by some of the coal explorations in Kent, and in particular by those at Dover, Brabourne, Pluckley, and Penshurst. The researches, of which the results are embodied in this memoir, were indeed commenced so long ago as 1897,

but the delay in publication can hardly be regretted, as fresh material was from time to time obtained, and the conclusions based upon an immense amount of careful detailed observation and study, are of the highest scientific interest and of considerable practical importance. Although permission to examine the material from the borings and shafts was given on the understanding that the investigations were not extended into the Coal-measures, nevertheless the information on the distribution and thicknesses of the various Mesozoic formations is all important in reference to the depth at which Palæozoic rocks are likely to be met with in areas hitherto unproved.

The memoir is divided into two parts of nearly equal length: the first, comprising "Stratigraphical Descriptions", is by Mr. Lamplugh; and the second, giving "The Palæontological Characters and Correlation of the Strata between the Gault Clay and the Trias", is by Dr. Kitchin. The four localities dealt with extend in almost a direct line from Penshurst, south-west of Tonbridge, to the Dover Coal-mine in Hougham parish, a distance of about forty-five miles. Records of these borings were published by Mr. Whitaker in his memoir on the *Water Supply of Kent* (1908), and a comparison of the information there given shows how much has been added with regard to the details and correlation of the strata.

At Dover, where the explorations were commenced in Chalk, less Folkestone Beds, more Sandgate Beds, and no Hythe Beds are recognized; and it is remarked by Mr. Lamplugh that there is "an intensified example of the condensation of sediments under strong current-action" in the case of the Folkestone Beds, as "although the Dover area remained beneath the sea during the accumulation of the Hythe Beds, the conditions were such that permanent sedimentation was not possible upon it". The attenuation of the Wealden Beds and the absence of Purbeck and Portland Beds are confirmed, and the unconformity is further marked by much erosion of the Kimeridge Clay. More Corallian is identified, the lower division, which is clayey and calcareous, being taken to include the *Cordatus* zone; and a less thickness is admitted of the Kellaways formation, which has yielded *Sigaloceras calloviense* at Tilmanstone. The Lower Oolites have been found capable of subdivision, and although Cornbrash is somewhat doubtfully distinguished strong support of the presence of the formation is afforded by fossils obtained from Tilmanstone north of Dover; the beds assigned to the Forest Marble also present some of the characters of that formation; the Great Oolite is clearly distinguished; and the Inferior Oolite may be represented by sands and calcareous grits which occur above the Upper Lias, but have yielded no fossils. The Upper Lias (*Serpentinus* zone), probably the Middle Lias (*Spinatus* zone), and the Lower Lias (*Capricornus* zone) are noted. Below come the Coal-measures.

At the Brabourne boring, commenced in Gault, another great series of formations has been proved, the records (with that of Dover), in the words of Mr. Lamplugh, being "unparalleled in Britain—or, so far as our knowledge goes, in any other part of the world—in the geological range and continuity of formations proved by them to exist in actual superposition in a single small area". The Folkestone

Beds, Sandgate Beds, possibly Hythe Beds, and Atherfield Clay are distinguished; but a less amount of Weald Clay than that given by Mr. Whitaker is now recorded. It is not surprising to those who have had to deal with well-borings, that difficulty is experienced in correlating the subdivisions of the Hastings Beds with those shown on the Geological Survey maps. Purbeck Beds are now introduced, and an illustration is given of a peculiar breccia similar to a bed exposed in the same formation at Hartwell and Haddenham in Buckinghamshire. The Portland Beds rest abruptly on the Kimeridge Clay, with indications of erosion, whereas at Pluckley and Penshurst these formations merge gradually one into the other. The Upper Corallian yields a band of "millet-seed iron-ore", as at Dover, but much reduced in thickness. The succession below is like that at Dover, with more Oxford Clay, subdivided into the *Mariæ*, *Renggeri*, and *Ornatus* zones, and there is a possible representative of the Fuller's Earth or Fullonian formation. The Upper Lias, as noted by Dr. Kitchin, includes not only the *Communis* zone, but also part of the *Jurensis* zone. *Rhynchonella tetrahedra* is definitely recorded from the Middle Lias, while the Lower Lias includes representatives of the *Capricornus*, *Jamesoni*, and possibly *Oxynotus* zones. No traces of Rhætic beds were discovered, but there was evidence of a good deal more Triassic marl and conglomerate than previously recorded, and these red rocks repose on mudstone, possibly of Devonian age.

At Pluckley the boring, commenced in Weald Clay, proved an unbroken sequence down to the Kimeridge Clay, and at Penshurst, commenced in Hastings Beds, a similar sequence was encountered. In both cases Purbeck and Portland Beds are now distinctly recognized and separated, with considerable increase in thicknesses at Penshurst, but it is admitted that the Portland Sand is represented in the Upper Kimeridge Clay. At Penshurst there are "greater thicknesses of Lower Wealden and Purbeck strata than have been proved at any other place within the Weald". Of Kimeridge Clay 622 feet was penetrated, probably not more than one-half of the total thickness, as the Penshurst site appears to lie near the central part of an old depression where the accumulation of sediment reached its maximum, and it is remarked that upon the thickness of this formation largely depends the success or failure of attempts to reach the Palæozoic floor in the south-east of England. An instructive diagram (plate iv) shows the arrangement and succession of the strata from Penshurst to Dover, and on it thick black lines indicate planes of original horizontality. From these data the earth movements can be studied, and it is apparent that the Wealden dome is "an anticline formed upon, or within the area of, an earlier syncline".

Dr. Kitchin has contributed some judicious remarks on the testimony afforded by fossils obtained from cores and shafts, the depths recorded being no positive indication of vertical range, while at many horizons fossils may occur in proximity to cores that were barren. Observations are made on the influence of sedimentary conditions and on certain species that appear to have a wide range in time. The value of recording generic names alone need not be questioned, as they may help to indicate the conditions under which strata were deposited.

An example may be taken from plate i, in which is figured a species of Pholadidea, the bored crypts of which descend from the base of the Sandgate Beds into the Atherfield Clay. Here the pause in deposition is indicated by the absence of the Hythe Beds, as previously noted.

Interesting lists of fossils are given from various horizons, from the *Mammillatus* Bed downwards, and comments are made on many species in reference to the vexed subject of nomenclature, on records of species new to this country, and on the limits of formations and epochs. The difficulty of fixing a definite plane of division is felt with the Corallian and overlying and underlying strata, as in Dorset; and so also with the Kimeridge Clay and Portland Beds, the French geologists, in their usage of the name Portlandian, having insufficiently realized the limits in the type-areas of England.

II.—Géologie du Bassin de Paris. Par M. Paul Lemoine. 8vo; pp. ii, 408, with 9 plates and 136 text-illustrations. Paris, Hermann & Fils; London, Dulau & Co., 1911. Price 15 fr.

IN this well-printed and well-illustrated work the author gives a comprehensive account of the stratigraphy, economic products, zonal palæontology, and physical geography of the Secondary, Tertiary, and Quaternary formations which, in a broad sense, constitute the Paris Basin.

After some preliminary remarks on general geology, he describes the main structural features of the basin. Then follow a short historical summary of the work of previous geologists, from Cuvier and Brongniart (1810) to the present time, and useful particulars of the geological survey maps, with names of the geologists responsible for them.

With the aid of palæographic and other maps and sections, the tectonic structure of the region, the areas of land and water at different periods, and the variations in sedimentary conditions of strata from the Trias onwards are expounded by the author. His objects are to give a faithful account of this interesting and important region from the knowledge scattered in many publications, to verify doubtful points, and where possible to decide differences of opinion. Illumined, as it is, with much additional information derived from the author's own researches, the result may be justly regarded as a standard work for study and reference.

In giving some account of this volume we propose to deal mainly with such points in the classification, nomenclature, and correlation of formations as may be of interest to our readers.

TRIAS. This system is divided as follows:—

Neotrias. Keuper and Marnes irisées.

Mesotrias. Muschelkalk.

Eotrias. Grès bigarré.

RHETIAN (or Rhætic Beds). These are placed independently as Passage Beds, and consist of arkoses, grits, sands, marls, and limestone, with the zonal *Avicula contorta*, also *A. infraliasiana*, *Leda Deffneri*, *Mytilus minutus*, *Myophoria*, *Psammobia*,

Diademopsis Heberti, etc. We are glad to note the preservation of the name *Avicula contorta*.

LIAS. Four stages are distinguished—

TOARCIAN. This is taken to include the Ammonite zones from that of *Harpoceras falciferum* to that of *H.* (*Lioceras*) *opalinum*, thus including not only equivalents of our Upper Lias but overlying Passage Beds (Midford Sands). It is noted that Professor E. Haug would include higher zones belonging to the basal portion of the English Inferior Oolite.[1]

CHARMOUTHIAN. This is taken to include the Ammonite zones from that of *Ægoceras Valdani* to that of *Amaltheus spinatus*, and is therefore equivalent to the higher part of our Lower Lias and the whole of our Middle Lias. The term Charmouthian is thus inappropriate, as the main portion of the English Middle Lias is not present in the Charmouth cliffs, and moreover the term has been used by Mr. S. S. Buckman for the zones from *Echioceras raricostatum* to *Liparoceras capricornus*. A term taken from a French locality would be preferable for the Paris Basin.

SINEMURIAN. This includes the Lower Lias Ammonite zones from that of *Arietites rotiformis* to those of *A. stellaris* and *A. obtusus*.

HETTANGIAN. This includes the basal Lower Lias zones of *Psiloceras planorbis* and *Arietites Burgundiæ*, and overlying zones of *A. liassicus* and *Schlotheimia angulata*.

A diagram-section from Longwy, west of Luxembourg, to Hirson, west of Mézières, shows the Bajocian overlapping the Toarcian in a westerly direction and resting directly on the Charmouthian. In the Cotentin the Charmouthian overlaps lower beds of the Lower Lias and rests directly on the Trias. Important beds of iron-ore occur in the higher part of the Toarcian in Lorraine in the zone of *Harpoceras* (*Grammoceras*) *aalense*.

LOWER JURASSIC (of author).[2]

BAJOCIAN. This series is rightly taken to include the strata from the zones of *Harpoceras Murchisonæ* and *H. concavum* (grouped together as Aalenian) to the zones of *Cœloceras subcoronatum* and *C. Blagdeni*, with overlying zones of *Cosmoceras Garantianum* and *Parkinsonia Parkinsoni* (grouped all together under the zone of *Oppelia subradiata*).

BATHONIAN. The zonal subdivisions (in descending order) are—

Bradfordian, with *Oppelia aspidoides*, *Œkotraustes serrigerus*, and *Oxynoticeras discus*.

Vesulian, with *Oppelia fusca*, *Morphoceras polymorphum*, and *Perisphinctes zig-zag*.

In Normandy the highest beds are equivalent to the Cornbrash, and the lowest (including the Caen stone) to the Fuller's Earth of

[1] See remarks of Professor J. Welsch, *Geology of Thouars*, noticed in GEOL. MAG., September, 1911, p. 419.

[2] The author regards the Lias as forming a separate system, and he uses the term Lower Jurassic in the sense in which Lower Oolitic is used in England.

England. Representatives of the Forest Marble and Bradford Clay are seen in the Calcaire à Bryozoaires (Pierre de Langrune) with *Dictyothyris coarctata*, *Magellania digona*, etc.

Callovian and Oxfordian. In this series the grouping in mass corresponds with that in England, but the Callovian is taken to include much more than the Kellaways Beds of this country, the Oxfordian being restricted by the author to the zone of *Cardioceras cordatum*. The intimate connexion between the Bathonian (Cornbrash, etc.) and the Corallian is shown by the fossils recorded from the lower and higher portions of the Callovian and Oxfordian respectively, on the western side of the Paris Basin.

Corallian. This variable series of strata is subdivided as follows, the species of Ammonites taken to mark zones differing from those adopted in England:—

Sequanian: Zone of *Perisphinctes Achilles*, associated with *Zeilleria humeralis*.

Rauracian: Zone of *P. Achilles*.
Zone of *Peltoceras bieristatum* and *Ochetoceras Marantianum*.

Argovian: Zone of *O. canaliculatum* and *Perisphinctes variocostatus*.[1]

The Corallian fossils vary in distribution according to the sedimentary nature of the strata. Thus *Perisphinctes plicatilis* occurs in Argovian limestones in the valley of the Yonne.

Kimeridgian. This includes the following zones:—
Zone of *Reineckeia eudoxus* and *Aspidoceras caletanum* (Upper Virgulian).
Zone of *A. orthocera* and *A. Lallierianum* (Lower Virgulian).
Zone of *Pictonia Cymodoce* (Pterocerian).

Portlandian. This includes—
Zone of *Perisphinctes bononiensis*.
Zone of *Stepheoceras portlandicum*.

It is noteworthy that *Hemicidaris purbeckensis* occurs in higher Portlandian of Haute-Marne and Meuse, where the uppermost strata yield *Pinna suprajurensis*, *Trigonia concentrica*, etc. In the Boulonnais the highest strata are noted as fluvio-lacustrine with *Physa*, *Planorbis*, etc., equivalent to part of our Purbeck. In lower stages there occur *Cyrena*, *Corbula*, *Trigonia*, *Perisphinctes giganteus*, etc.

(*To be concluded in our next Number.*)

III.—The Flora of the Raritan Formation. By E. W. Berry. Bull. III, Geol. Surv. New Jersey, 1911. pp. 1–233, with 29 plates.

THIS noteworthy contribution to the study of the Cretaceous floras of the United States is in the main a revision of Newberry's posthumous monograph, *The Flora of the Amboy Clays*. In addition several new plants, as well as species from new localities, are described,

[1] This species, described by Buckland as *Ammonites variocostatus* in his "Bridgewater Treatise", is usually spelt *varicostatus* in English works.

and the number of forms now known from the Raritan formation = Amboy Clays is between 160 and 170. The ferns are particularly interesting and varied, several being referred to the genera *Gleichenia*, *Dicksonia*, *Asplenium*, and *Ophioglossum*. The Cycads are represented by numerous members of the genus *Podozamites*, and a species of *Microzamia*. The Coniferæ are referred to the genera *Dammara*, *Brachyphyllum*, *Thuja*, *Sequoia*, and *Widdringtonites* among others. The Ginkgoales are represented by *Baiera* and *Czekanowskia*. Only a single Monocotyledon is recorded, but the Dicotyledons, as is invariably the case in Upper Cretaceous floras, are both very numerous and very varied, and far outnumber the representatives of all other groups. Among the Dicotyledonous leaf-impressions figured are good examples of the leaves of *Magnolia*, *Liriodendron*, and *Sassafras*, as well as those of *Salix* and *Populus*. A general account of the Raritan formation and its correlation is added, and the distribution of the species described, in time and space, is also adequately considered. On the whole the memoir appears to be a sound piece of work, noteworthy in that the author has obviously rejected as unsatisfactory the less perfect specimens in the collections which he describes, and he has thus avoided the common error of making much of material which is often quite unworthy of description.

E. A. N. A.

IV.—Geological Survey of the United States.

WATER-SUPPLY Papers Nos. 263, 266, 267, and 268 (1911) contain accounts of the surface water in the basins of the Ohio, Missouri, Lower Mississippi, and in the western Gulf of Mexico. In the introductory portions of these memoirs there are useful definitions of terms used in hydraulic computations; descriptions of the methods of measuring stream-flow, with illustrations; descriptions of the river basins, with details of gaugings; and illustrations of rivers, waterfalls, canals, wasteway gates, dams, and headworks.

Water-Supply Paper No. 273 (1911) is on the Quality of the Water Supplies of Kansas, by Mr. H. N. Parker, with report on stream pollution through mine-waters, by Mr. E. H. S. Bailey. No. 275 (1911) is on the Geology and Water Resources of Estancia Valley, New Mexico, by Mr. O. E. Meinzer. The physiography and geology of the district are described; there are accounts of wind-deposited clay, of alkali and other soils, and of methods of irrigation. The subjects are illustrated by maps and photographic views.

No. 276 (1911) contains an account of the Geology and Underground Waters of North-Eastern Texas, by Mr. C. H. Gordon, with illustrations and geological map.

No. 277 (1911), on Ground Water in Juab, Millard, and Iron Counties, Utah, by Mr. O. E. Meinzer, contains much interesting information on physiography and geology, on the soils and vegetation, on the relation of rainfall to dry-farming, on the ground and artesian water in igneous and sedimentary rocks, in lakes and valleys, and on desert flats. Springs, hot and cold, and irrigation are dealt with, and there are many illustrative maps and diagrams.

Bulletin No. 479 (1911) is by Mr. Chase Palmer on the Geochemical Interpretation of Water Analyses, and it is pointed out "that the statement of water analyses in a form which does not recognize the *proportional reaction capacity* of the radicles fails to show the chemical character of the waters".

Bulletins Nos. 454 and 456 (1911) contain accounts of the Coal, Oil, and Gas of the Foxburg Quadrangle, and of the Oil and Gas Fields of the Carnegie Quadrangle, Pennsylvania.

Bulletin No. 475 (1911), by Messrs. J. E. Gilpin and O. E. Bransky, gives the results of experiments on the diffusion of Crude Petroleum through Fuller's Earth. It is found that the earth tends to retain the unsaturated hydrocarbons and sulphur compounds in petroleum, and very probably it retains largely the nitrogen compounds in the oil.

V.—Bibliography of the Foraminifera.

Paläontologisch - stratigraphische und zoologisch - systematische Literatur über marine Foraminiferen fossil und rezent bis Ende 1910. Zusammengestellt von Dr. Karl Beutler, Paläontologe in München. (Privately printed and sold by the author, price 3*s*., and postage 3*d*.) 8vo; pp. 144.

THIS is a useful compilation from Woodward, Sherborn, and Tutkovski, with much additional matter, thrown into an alphabetical list and divided up in the last few pages into Geological, Morphological, Systematic, Bibliographical, Geographical Distribution, Catalogues, and other headings, referring the reader by numerals back to the author list of papers. It apparently takes little or no notice of bibliographical details, and omits those painfully brought together by Sherborn, as well as all pagination of the works quoted from. It is also inaccurate in many particulars, notably in the omission of Lister's valuable contribution to the Zoology edited by Lankester, and of any reference to the first edition of Fichtel & Moll, etc. Further, the entry of an author's name as Cuvier, Fichtel, Diesing, Cross, Flint, Schroeter, and so on, is misleading, and only causes confusion. In all works of this nature the full names of the authors are essential, and in most cases easily ascertainable.

The book will be serviceable, however, if carefully used, and we thank Dr. Beutler for putting it together.

VI.—Brief Notices.

1. Thermal Waters in the Yellowstone National Park.—The origin of these waters is discussed by Mr. Arnold Hague (*Science*, N.S., xxxiii, p. 553, 1911), who maintains that they are not primitive in their origin, but are due to vadose or surface waters that have penetrated to a sufficient depth to attain a temperature that would force them again to the surface in the form of boiling springs and aqueous vapours. This conclusion is based on the nature and structure of the rocks through which the heated waters reach the surface, on the mineral constituents of the waters, and those in the sediments and incrustations deposited around springs and pools, and on the composition of the gases.

2. Crinoids.—A Trenton Echinoderm Fauna at Kirkfield, Ontario (Canada, Dept. Mines, Mem. 15 P., 1911), is discussed by Frank Springer. It yielded forty or more species, most of which were originally described by Elkanah Billings, but one is new (*Ottawacrinus billingsi*).

3. Dr. A. H. Clark discusses the systematic position of *Marsupites* in Proc. U.S. Nat. Mus., xl, 649–54, 1911; and Springer has a paper on the Crinoid fauna of the Knobstone formation in the same journal, vol. xli, pp. 175–208. Dr. Clark considers *Marsupites* to have been a pelagic comatulid and compares it and *Uintacrinus* with *Antedon* and other crinoids which have pelagic stages. He insists that *Marsupites* and *Uintacrinus*, unlike *Antedon*, were always, at all stages, free-swimming animals.

REPORTS AND PROCEEDINGS.

Geological Society of London.

January 10, 1912.—Professor W. W. Watts, Sc.D., LL.D., M.Sc., F.R.S., President, in the Chair.

The following communication was read:—

"On a Late Glacial Stage in the Valley of the River Lea, subsequent to the Epoch of River-Drift Man." By S. Hazzledine Warren, F.G.S. With Reports on the Flowering Plants, by Francis J. Lewis, M.Sc., F.L.S.; on the Mosses, by H. N. Dixon, M.A., F.L.S.; on the Mollusca, by Alfred Santer Kennard, F.G.S., and Bernard Barham Woodward, F.L.S., F.G.S.; on the Coleoptera, by C. O. Waterhouse, I.S.O., F.E.S.; on the Entomostraca, by D. J. Scourfield, F.R.M.S.; and on the Microscopic Examination of the Sandy Residue, by George Macdonald Davies, F.G.S.

The paper describes a carbonaceous deposit, discovered by the author, which is embedded in the low-level River-Drift gravel of the Lea Valley, in the neighbourhood of Ponders End. It belongs to the close of the Pleistocene Period, and is very much later than the Moustierian deposits. It may be of Magdalenian age, but there is no evidence to suggest this. It is more probably post-Magdalenian, formed during the time of the supposed archæological hiatus between the Palæolithic and the Neolithic Epochs. The deposit yields a varied fauna and flora, which has been the subject of extended investigation. The results of this are embodied in the reports which are appended to the paper. The conclusions arrived at in these reports are in close agreement with each other, and indicate climatic conditions similar to those now found in Lapland. The evidence of this comparatively late Arctic climate in the South of England is important. It throws much light on many vexed questions, particularly with regard to the relationship of Palæolithic man to the Glacial Period. It may have been the Arctic conditions represented by the Ponders End stage (as it might appropriately be named) which caused the migration of Palæolithic man to less inclement regions. The correlation is also suggested between the Ponders End stage and the 'Trail' of the Rev. O. Fisher. The evidence is further interesting, as showing another important fluctuation of climate during the Pleistocene Period.

MINERALOGICAL SOCIETY.

January 23.—Professor W. J. Lewis, F.R.S., President, in the Chair.

Miss M. W. Porter and Dr. A. E. H. Tutton: The Relationship between Crystalline Form and Chemical Constitution: The Double Chromates of the Alkalies and Magnesium. The investigation of the crystals of ammonium-magnesium chromate containing $6\,H_2O$, and of those of the analogous salts containing rubidium and cæsium (the formation of the corresponding potassium salt being impossible), shows not only that the double chromates belong to the same monoclinic series as the double sulphates and selenates previously investigated by Dr. Tutton, but that their mutual relationships are precisely parallel to those afforded by the other groups of the series. The rubidium and cæsium salts exhibit the same progressive changes of morphological and physical properties in the same direction as the rubidium and cæsium salts of all the other groups investigated, so that if the potassium salt could be prepared the three salts would undoubtedly form a eutropic group progressive in properties in accordance with the atomic weights of the three alkali metals, and it is even possible to predict the properties of the missing potassium salt. As in all the other cases, the ammonium salt is isomorphous and not eutropic. Moreover, the double chromates are isomorphous and not eutropic with the eutropic sulphates and selenates.—Professor W. J. Lewis: On a lead-grey Sulpharsenite from Binn, probably Liveingite. The crystals have two prominent zones mutually inclined at 90°, the one markedly oblique and the other prismatic in symmetry. Assuming oblique symmetry, the face-symbols are very high numbers; assuming anorthic symmetry, they are simple, but the crystals possess several relations characteristic of oblique symmetry, and twinning, though undoubtedly occurring, is not a satisfactory explanation.—R. H. Solly and Dr. G. F. H. Smith: A new Anorthic Mineral from the Binnental. Since no further crystals have come to light similar to the five minute ones found in 1902 by Mr. Solly on a crystal of, probably, rathite, they have recently been remeasured. They are lead-grey and their streak is chocolate in colour, and they are therefore probably a sulpharsenite of lead. No axes or plane of symmetry were observed, and the symmetry is therefore anorthic. The fundamental constants are $a : b : c = 0{\cdot}9787 : 1 : 1{\cdot}1575$; $\alpha = 116°\ 53\frac{1}{2}'$, $\beta = 85°\ 12'$, $\gamma = 113°\ 44\frac{1}{2}'$; $010 : 001 = 62°\ 41'$, $001 : 100 = 83°\ 4\frac{1}{2}'$, $100 : 010 = 65°\ 46'$; and about twenty-one forms were observed, of which the most prominent are 100, 010, 001, $\bar{1}10$, $1\bar{1}1$, $11\bar{1}$.—Dr. A. Hutchinson: On Colemanite and Neocolemanite. By a slight change in the orientation adopted for the crystals of the latter mineral its crystallographic and optical properties can be brought into harmony with those of the former. This can be effected by a rotation of the crystal through 180°, about the normal, to the face 001, 100 of neocolemanite, then coinciding with $\bar{2}01$ of colemanite.—Dr. A. Hutchinson and Dr. A. E. H. Tutton: Further observations on the Optical Characters of Gypsum. With the aid of new apparatus by which the section-plate of gypsum perpendicular to the first median line can be surrounded during observations of the interference figure by flowing hot water, of which

the temperature is accurately recorded both immediately before and after passing the crystal, the authors have been able to prove definitely that the temperature at which gypsum becomes uniaxial is for sodium light 91°, for red C and greenish-blue F hydrogen light 89°, and for the violet hydrogen line near G 87°. These temperatures agree precisely with those observed for the exact superposition of the pair of images of the spectrometer slit, afforded by a 60° prism cut to give the a and β refractive indices. Owing to the large correction necessary for conduction of the crystal holder when the ordinary Fuess air-bath heating apparatus was employed, and to the difficulty in determining it, former determinations of the temperature at which a section-plate of gypsum becomes uniaxial were too high, and did not agree with the prism observations.—Dr. G. F. H. Smith: Note on a large Crystal of Anatase from the Binnental. The crystal exhibits a combination of the forms a (100), τ (313), and z (113), and the others not prominent, and it is remarkable for the fact that the faces τ have been entirely replaced by numberless tiny crystals with the forms z (113), k (112), p (111), and e (101), and the same orientation as the large crystal.

CORRESPONDENCE.

THE DRAWING ON A RED CRAG SHELL.

Sir,—I think we shall do well to be cautious in recognizing a "long-lost brother" in the Red Crag, though his credentials have been accepted by no less an authority than Sir E. Ray Lankester. At any rate I doubt whether the carving on a shell of *Pectunculus glycimeris*, cited in your last number by Dr. M. C. Stopes, strengthens the evidence in favour of his existence. I had the opportunity of examining this a few years ago and possess a photograph, which Mrs. Stopes kindly gave me at that time. The design and execution of the engraving reminded me rather of a piece of grotesque, dating from the nineteenth century, than of the efforts of Palæolithic man, as displayed on the walls of caves or in other relics of his handywork. That, however, is a matter of opinion, but what weighed even more with me when I examined the specimen was the state of the shell and the carvings. The former, especially its hinge-teeth, showed the very slight corrosion usual in Crag specimens of this *Pectunculus*, while the surface of the carved parts was smooth and comparatively fresh-looking. I do not doubt that the late Mr. Stopes was convinced that he had obtained possession of a genuine relic of Red Crag Man, but, if we could trace out the history of the specimen before it came into his hands, I think we should find this another instance of an "old friend with a new face".

T. G. Bonney.

STRATIGRAPHICAL NAMES.

Sir,—It is probable that few geologists whose studies are limited to a single country, or even to a single continent, have any adequate conception of the large number of names that have been proposed either for geological formations or for periods of geological time.

I do not myself know how many such names there are, but my card-index to them, incomplete though it unfortunately is, already extends to a thickness of over two yards. From this simple fact certain consequences follow.

In the first place it is impossible for those of us who have to deal with formations of every age and from all quarters of the globe to carry in our heads the numerous names that have been proposed for them. A card-index, such as that to which I have referred, is an almost indispensable aid to one's work, and it is very necessary to keep it up to date. But since few workers possess such a card-index, there is an ever-increasing chance that those names which are yearly, one might say daily, proposed, will be already utilized in some other sense. New names continue to appear in all languages and in publications of most diverse standing, including many that have an extremely limited and local circulation. And just as there is no restriction on the part of publications, neither does there seem to be any on the part of the worker who thinks himself entitled to propose such new names. Not only are they proposed by recognized official bodies, such as national surveys, but also by individual geologists of every degree of competence. Thus, the chances that the names will be unsuitable at the outset and overlooked afterwards are greatly increased.

To give one or two examples out of many—a British geologist, familiar with the Bradford Clay and with the time-name 'Bradfordian', proposed by Desor in 1859, would not be likely to understand or to sympathize with a modern American proposal to apply the same term to some Lower Carboniferous beds in New York. Again, a French or German geologist who has been taught that the term 'Stonesfield slate' denotes certain 'schistes jurassiques inférieures d'Angleterre', runs the risk of being considerably misled when, in a recent memoir on the geology of Jura and the surrounding districts, he comes upon the term 'Stonefield schists' applied to some metamorphic rocks of considerably greater age.

Now, Sir, the object of this letter is not merely to indulge my love for a grumble, but to suggest to the geologists of Britain, at any rate, two ways by which they might help themselves and others.

A paper recently issued by an American colleague states that certain formational names therein proposed have previously been submitted to an official committee on Geological Nomenclature, and have received its approval. Would it not be possible to have such a committee in this country, nominated, perhaps, by the Geological Survey and the Geological Society? The decrees of a committee, however authoritative, could have no binding force, but its existence might act as a deterrent to the irresponsible and as an aid to the conscientious worker. It would be the business of the committee to make itself familiar with the names already proposed in this and other countries, and to prevent such sources of confusion as the two mentioned above.

The second suggestion is that every British geologist who proposes a new name, whether it be in a memoir of the Geological Survey, in the Quarterly Journal of the Geological Society, or in the Proceedings of the Little Muddleborough Field Club, should be invited to send the

name, together with a definition, to the Editor of the GEOLOGICAL MAGAZINE. These names might be combined into a single list at the end of each year, or possibly published at more frequent intervals, according to the discretion of the Editor. It may, perhaps, be pointed out to me that, since the International Catalogue of Scientific Literature has a section for Geology, that would be the proper place for indexing such names. Agreed! But all the same the suggestion is not a practical one so long as that particular volume of the International Catalogue is thrown together (one cannot say 'edited') on its present lines.

These proposals are the best that occur to me at present. Should they give rise to any discussion and to any better proposals, I shall be glad; but whatever be the upshot of discussion I wish to insist that it is really time for something to be done.

F. A. BATHER.

OBITUARY.

GEORGE MAW, F.L.S., F.S.A., F.G.S.

BORN 1832. DIED FEBRUARY 7, 1912.

THE death is announced of George Maw, at Benthall, Kenley, Surrey, and formerly of Benthall Hall, Broseley, Shropshire, aged 79. Mr. Maw, who for many years was a manufacturer of encaustic tiles at Broseley, took an early interest in geology, became a Fellow of the Geological Society in 1864, and a valued contributor to the pages of the GEOLOGICAL MAGAZINE, from the first volume in 1864 to 1878.

His first communication, read before the Geological Society in 1864, was on the drift-deposits of the Valley of the Severn, and it was followed by one on the potter's clay of Fremington near Barnstaple, a deposit which Maw was disposed to regard as of Glacial age. In 1865 he described in the GEOLOGICAL MAGAZINE some deposits of Chert, White Sand, and White Clay, which occurred in pockets in the mountain-limestone of Llandudno. In 1867 he brought before the Geological Society observations "On the Sources of the Materials composing the White Clays of the Lower Tertiaries", and in the following year a paper "On the Disposition of Iron in variegated Strata", illustrated by coloured plates and many diagrams and analyses. This undoubtedly was his most important contribution to geological science, and arrested the attention and won the warmly expressed admiration of Professor Ruskin, who was enchanted with the beauty of coloration and variegation in arrangement and banding displayed in the sections illustrating this very valuable work.[1]

In 1876 he published in the third edition of the Catalogue of Specimens of British Pottery and Porcelain in the Museum of Practical Geology, an instructive and practical appendix on a series of specimens which he had collected in order to illustrate the Clays and Plastic Strata of Great Britain.

[1] See Quart. Journ. Geol. Soc., vol. xxiv, pp. 351–400, pls. xi–xv, and 24 woodcuts, 1868.